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- Tsuyoshi, Higuchi  
Ota-shi, Gumma-ken (JP)
- Kazuaki, Fujiwara  
Ota-shi, Gumma-ken (JP)
- Keijiro, Igarashi  
Ota-shi, Gumma-ken (JP)
- Masaaki, Takezawa  
Nitta-gun, Gumma-ken (JP)
- Kazuhiko, Arai  
Nitta-gun, Gumma-ken (JP)

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(71) Applicant: **Sanyo Electric Co., Ltd.**  
**Moriguchi-shi, Osaka (JP)**

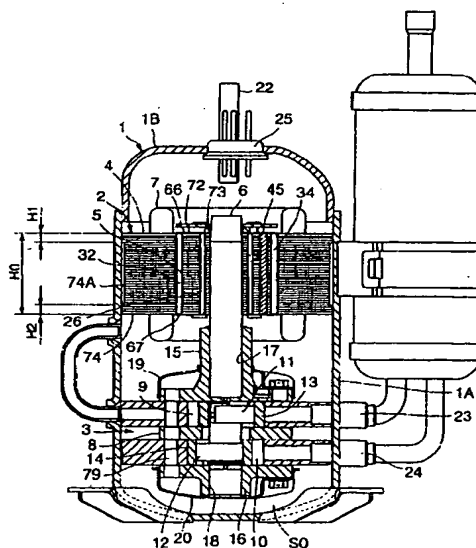
(72) Inventors:  
• Kenzo, Matsumoto  
Ora-gun, Gumma-ken (JP)  
• Manabu, Takenaka  
Ora-gun, Gumma-ken (JP)

(74) Representative: **Glawe, Delfs, Moll & Partner**  
**Patentanwälte**  
**Postfach 26 01 62**  
**80058 München (DE)**

(54) **Motor compressor and cooling apparatus using the same**

(57) An objective of the present invention is to provide a motor compressor that reduces noise by lessening a contact area between a stator and a shell, wherein a motor element is constituted of a stator having a stator core that contacts and is fixed to an internal wall of the closed vessel, and a rotator having a magnetic substance, which is attached to the rotating shaft and is rotatably supported in the inside of the stator construct. It is essential that  $H < H_0$  is satisfied wherein  $H$  is a dimension in a rotating shaft direction of an area in which the stator core contacts the closed vessel and  $H_0$  is a dimension in a rotating shaft direction of the stator core.

FIG.1



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## Description

## BACKGROUND OF THE INVENTION

## (i) Field of the Invention

[0001] The present invention relates to a motor compressor comprising a motor element and a compression element which is driven by a rotating shaft connected to the motor element in a closed vessel.

## (ii) Description of the Related Art

[0002] Heretofore, this kind of motor compressor has been disclosed in Japanese Patent Application Laid-Open Nos. 288180/1998 (FO4C29/00) and 350444/1993 previously filed by the present applicant. An induction motor, a DC motor, and so forth are used as the motor of the conventional motor compressor, but the DC motor is designed so that a laminated thickness of a permanent magnet and a rotor is the same as that of a stator in case that it is a rare earth permanent magnet motor, and the laminated thickness of the rotator and the permanent magnet is higher than that of the stator in case that it is a ferrite permanent motor.

[0003] Next, this conventional type of the motor 100 will be explained by use of FIG. 21 and FIG. 22. A closed vessel 101 in the drawings contains a motor 102 (e.g., a DC motor) as the motor element in the internal upper side thereof, and a compression element 103 being rotatably driven by this motor 102 in the lower side. The closed vessel 101, which comprises a cylindrical shell 101A with the upper end thereof opened, and an end cap 101B that clogs the upper end opening of the shell 101A, is a two-section configuration and is configured by capping the cylindrical shell 101A with the end cap 101B to close it with a high frequency deposition and so forth after containing the motor 102 and the compression element 103 within the shell 101A. Furthermore, the bottom within the shell 101A of this closed vessel 101 becomes an oil gathering SO.

[0004] The motor 102 is constituted of a stator 104 fixed to the internal wall of the closed vessel 101 and a rotator 105 with a rotating shaft 106 centered rotatably supported in the inside of this stator 104. The stator 104 is constituted of a stator core 174 configured by laminating a plurality of steel sheets for a stator sheets with almost a donut shape, and a stator winding (drive coil) 107 for applying rotating magnet field to the rotator 105, which is mounted with a distributed winding technique on a plurality of teeth formed in an internal periphery of this stator core 174. Moreover, the peripheral surface of this stator core 174 contacts and is fixed to the internal wall of the shell 101A of the closed vessel 101.

[0005] In this case, a plurality of notches 176 are formed in the peripheral surface of the stator core 174, and these notches 176 are spaced from the internal wall of the shell 101A, wherein a path 177 is configured.

[0006] The compression element 103 comprises a first cylinder for a rotary 109 and a second cylinder for a rotary 110 separated by an intermediate parting stop 108. To each of the cylinders 109 and 110 is attached eccentrics 111 and 112 being rotatably driven by the rotating shaft 106, and each eccentricity of the eccentrics 111 and 112 is 180° degree out of phase from the other.

[0007] 113 and 114 are a first roller and a second roller that rotate within the cylinders 109 and 110 respectively, and each rotates within the cylinders by the rotation of the eccentrics 111 and 112 respectively. 115 and 116 are a first frame and a second frame, the first frame 115 causes compressed air to be formed between the parting stop 108 and it with the cylinder 109 closed, and the second frame 116 also causes compressed air to be formed between the parting stop 108 and it with the cylinder 110 closed. Furthermore, the first frame 115 and the second frame 116 comprise bearings 117 and 118 respectively that rotatably and axially support the lower portion of the rotating shaft 106.

[0008] 119 and 120, which are cap mufflers, are attached so as to cover the first frame 115 and the second frame 116. In addition, the cylinder 109 and the cap muffler 119 are in communication by a communicating hole (not shown) provided in the first frame 115, and the cylinder 110 and the cap muffler 120 are also in communication by a communicating hole (not shown) provided in the second frame 116. 121, which is a bypass pipe provided outside the closed vessel 101, is in communication with the internal side of the cap muffler 120.

[0009] 122 is a vent pipe provided on the top of the closed vessel 101, and 123 and 124 are suction pipes that connect to the cylinders 109 and 110 respectively. Furthermore, 125, which is a closed terminal, is for supplying a power from the external side of the closed vessel 101 to the stator winding 107 (a lead wire that connects the closed terminal 125 and the stator winding 107 is not shown in the Fig).

[0010] A rotator core 126 of the rotator 105 has a plurality of steel sheets for a rotator with a predetermined shape stamped from magnetic steel sheets with thickness 0.003 mm to 0.007 mm to be laminated to caulk each other for integration.

[0011] In this case, the steel sheets for a rotor of the rotator core 126 are stamped from magnetic steel sheets so that salient poles 128, 129, 130 and 131 are formed that construct a quadrupole, and 132, 133, 134 and 135 are

concavities provided so that the salient poles are formed between each of the salient poles 128, 129, 130 and 131, and the other respectively.

[0012] Slots 141, 142, 143 and 144 for inserting a magnetic substance 145 (permanent magnet) correspond to each of the salient poles 128, 129, 130 and 131, respectively, and they are concentrically slotted on the periphery side of the rotator core 126 along the direction of an axis of the rotating shaft 106.

[0013] Furthermore, a hole 146, into which the rotating shaft 106 is shrink-fitted, is formed at the center of the rotator core 126. Each rotator core 126 is formed by caulking each other for integration after laminating a plurality of steel sheets for a rotator.

[0014] The magnetic substance 145 set forth above is constituted of a rare earth magnetic material such as a praseodymium magnet material or a neodymium magnetic material whose surface is plated with nickel or the like, and the external shape thereof is to be a profile rectangle, and, as a whole, to be rectangular. Each of the slots 141, 142, 143 and 144 is to be sized so that this magnetic substance 145 is inserted. Moreover, 166 and 167, which are flat-shape end members being attached to the upper and the lower end of the rotator core 126, are formed of non-magnetic materials such as stainless steel, brass or the like in a nearly disc shape.

[0015] In addition, 172, which is located above the end member 166, is a disc-shape plate for separating oil attached to the rotator 105, and 173 is a balancing weight attached between the plate 172 and the end surface 166.

[0016] In such a configuration, when a power is applied to the stator winding 107 of the stator 104 of the motor 102, rotating magnetic field is formed to rotate the rotator 105. Rollers 113 and 114 within the cylinders 109 and 110 is eccentrically rotated via the rotating shaft 106 by this rotation of the rotator 105, and suction gas sucked from the suction pipes 123 and 124 is compressed.

[0017] The compressed high-pressure gas is vented within the cap muffler 119 from the cylinder 109 via the communicating hole, and is vented within the closed vessel 101 from the vent hole (not shown) formed in this cup muffler 119. On the other hand, from the cylinder 110, the compressed high-pressure gas is vented into the cup muffler 120 via the communicating hole, and is vent into the closed vessel 101 through the bypass pipe 121.

[0018] The vented high-pressure gas passes through a gap within the motor 102 to reach the vent pipe 122, and vented to the external side. On the other hand, oil is contained in the gas, but this oil, which is separated by the plate 172 and the like until it reaches the vent pipe 122, is directed externally by a centrifugal force, and flows down to the oil gathering SO through the path 177.

[0019] Such a motor 102 provided in the motor compressor 100 has been designed so that, in case that the magnetic substance 145 is a rare earth permanent magnet, a thickness dimension of a permanent magnet and the rotator 105, and a laminated thickness of the stator 104 are almost the same, and in case that the magnetic substance 145 is a ferrite permanent magnet, the laminated thickness of the permanent magnet and the rotator 105 is higher than that of the stator 104.

[0020] However, in the DC motor (electric motor) for use in the motor compressor, a radial magnetic attraction / repulsion force of the stator is big, as compared with a normal reduction motor. For this reason, a yoke of the motor is shaken, which has been a factor to the increase in noise of the motor compressor. In particular, in the motor using a rare earth permanent magnet with a high magnetic force and in a magnetic-pole concentrated winding motor having less number of slots, variation in magnetic flux is bigger than that of a motor having much slots, and accordingly the problem existed that the noise reduction is a big task.

[0021] In addition, the vibration shaken at the teeth of the stator core shook the yoke of the stator to directly vibrate the shell at the contact area to the shell. The problem existed that this is also a factor to the increase in noise of the motor compressor.

## SUMMARY OF THE INVENTION

[0022] The present invention has been accomplished to solve such conventional tasks, and an objective of the present invention is to provide a motor compressor that can drastically reduce noise by lessening a contact area between a stator and a shell.

[0023] Namely, a first aspect of the present invention is directed to a motor compressor comprising a motor element and a compression element which is driven by a rotating shaft connected to the motor element in a closed vessel, wherein the motor element is constituted of a stator having a stator core that contacts and is fixed to the inside wall of the closed vessel, and a rotator having a magnetic substance which is attached to a rotating shaft and rotatably supported in the inside of the stator; and  $H < H_0$  is satisfied wherein  $H$  is a dimension in a rotating shaft direction of an area in which the stator core contacts the closed vessel, and  $H_0$  is a dimension in the rotating shaft direction of the above stator core.

[0024] Furthermore, a second aspect of the present invention is directed to a motor compressor comprising a motor element and a compression element which is driven by a rotating shaft connected to the motor element in a closed vessel, wherein the motor element is constituted of a stator having a stator core that contacts and is fixed to the inside

wall of the closed vessel, and a rotator having a magnetic substance which is attached to a rotating shaft and rotatably supported in the inside of the stator; and  $H_{mg} < H_o$  is satisfied wherein  $H_{mg}$  is a dimension of the magnetic substance in the direction of the rotating shaft and  $H_o$  is a dimension of the above stator core in the direction of the rotating shaft.

[0025] In addition, a third aspect of the present invention is directed to a motor compressor comprising a motor element and a compression element which is driven by a rotating shaft connected to the motor element in a closed vessel, wherein the motor element is constituted of a stator having a stator core that contacts and is fixed to the inside wall of the closed vessel, and a rotator having a magnetic substance which is attached to the rotating shaft and rotatably supported in the inside of the stator; and  $H < H_o$  and  $H_{mg} < H_o$  are satisfied wherein  $H$  is a dimension in a rotating shaft direction of an area in which the stator core contacts the closed vessel,  $H_o$  is a dimension in the rotating shaft direction of the above stator core, and  $H_{mg}$  is a dimension of the magnetic substance in the direction of the rotating shaft.

[0026] Furthermore, in addition to the first to third inventions, the motor compressor of the present invention is configured to set a ratio of a dimension  $H$  to a dimension  $H_o$  at  $0.2 \leq H/H_o \leq 0.8$ .

[0027] In addition, in addition to the second and third inventions, the motor compressor of the present invention is configured to set a ratio of a dimension  $H_{mg}$  to a dimension  $H_o$  at  $0.2 \leq H_{mg}/H_o \leq 0.98$ .

[0028] Furthermore, in addition to the above-mentioned inventions, in the motor compressor of the present invention, the magnetic substance is constituted of the rare earth magnetic material; and a ratio of  $L$  to  $D$ ,  $L/D < 1.1$  is satisfied wherein  $L$  is a dimension of the above rotator core in the direction of the rotating shaft and  $D$  is a diameter of the rotator core of the rotator; and a ratio of  $t$  to the dimension  $H_{mg}$ ,  $t/H_{mg} < 0.1$  is satisfied wherein  $t$  is a thickness dimension of the magnetic substance.

[0029] Additionally, the present invention is directed to a cooling apparatus in which a refrigerant circuit is constituted of the motor compressor of the above-mentioned invention, a condenser, a pressure reducing apparatus and an evaporator.

#### BRIEF DESCRIPTION OF THE DRAWINGS

[0030] FIG. 1 is a longitudinally sectional side view of a motor compressor of the present invention with notches provided in a rotator in the circumferential direction of a rotating shaft.

[0031] FIG. 2 is a cross sectional top view of the motor compressor of the same FIG. 1.

[0032] FIG. 3 is a longitudinally partial sectional side view of a rotator of the present invention.

[0033] FIG. 4 is a plan view of a rotator of the present invention.

[0034] FIG. 5 is a plan view of a steel sheet for a rotator that constructs a rotator of the present invention.

[0035] FIG. 6 is a side view of a rotator core that constructs a rotator of the present invention.

[0036] FIG. 7 is an oblique view of a magnetic substance that constructs a rotator of the present invention.

[0037] FIG. 8 is a diagram illustrating a demagnetization curve of a permanent magnet that is used as a magnetic substance.

[0038] FIG. 9 is a diagram illustrating a waveform of noise of a motor compressor of the present invention with notches provided in a rotator in the circumferential direction of a rotating shaft.

[0039] FIG. 10 is a longitudinally sectional side view of one more motor compressor.

[0040] FIG. 11 is a cross sectional top view of a motor compressor of FIG. 10.

[0041] FIG. 12 is a longitudinally sectional side view of one more motor compressor.

[0042] FIG. 13 is a cross sectional top view of a motor compressor of FIG. 12.

[0043] FIG. 14 is a longitudinally sectional side view of one more motor compressor.

[0044] FIG. 15 is a cross sectional top view of a motor compressor of FIG. 14.

[0045] FIG. 16 is a longitudinally sectional side view of one more motor compressor of the present invention configured so that a magnetic substance provided in a rotor is shorter than a stator.

[0046] FIG. 17 is a cross sectional top view of a motor compressor of FIG. 16.

[0047] FIG. 18 is a diagram illustrating a waveform of noise of a motor compressor configured so that a magnetic substance provided in a rotor is shorter than a stator.

[0048] FIG. 19 is a longitudinally sectional side view of one more motor compressor of the present invention configured so that notches are provided in a rotator in the circumferential direction of a rotating shaft and simultaneously a dimension of a magnetic substance provided in a rotor is shorter than that of a stator.

[0049] FIG. 20 is a cross sectional top view of a motor compressor of FIG. 19.

[0050] FIG. 21 is a cross sectional side view of a conventional motor compressor.

[0051] FIG. 22 is a cross sectional top view of a motor compressor of FIG. 21.

[0052] FIG. 23 is a refrigerant circuit diagram of a cooling apparatus using a motor compressor of the present invention.

## ETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

**[0053]** Next, an embodiment of the present invention will be explained based on the drawings. In FIG. 1 and FIG. 2, a closed vessel 1, that constructs a cooling apparatus provided in a freezing warehouse, a refrigerator, a showcase or the like, has a motor 2 as a motor element in the internal upper side thereof, and a compression element 3 being rotatably driven by this motor 2 in the upper side thereof to be contained. The closed vessel 1, which comprises a cylindrical shell 1A with the upper end thereof opened and an end cap 1B that clogs the upper end opening of this shell 1A, is a two-section configuration, and is configured by capping the cylindrical shell 1A with the end cap 1B to close with a high frequency deposition and so forth after containing the motor 2 and the compression element 3 within the shell 1A. Moreover, the bottom within the shell 1A in this closed vessel 1 becomes an oil gathering SO.

**[0054]** The motor 2, which is a DC brush-less series motor with what is called a magnetic-pole concentrated winding technique, is constituted of a stator 4 that is fixed to the internal wall of the closed vessel 1, and a rotator 5 with the rotating shaft 6 centered rotatably supported in the inside of this stator 4. Moreover, the stator 4 is constituted of a stator core 74 configured by laminating a plurality of donut-shape stator steel sheets (silicon steel sheet), and a stator winding (drive coil) 7 for applying rotating magnet field to the rotator 5.

**[0055]** In the internal periphery of the stator core 74 are provided six (6) teeth (not shown), and slots 78 which are opened internally, and above and below, are formed among these teeth. In addition, by winding in series the stator winding 7 on these teeth, using space of the slots 78, to form magnetic poles of the stator 4 with what is called a magnetic-pole concentrated winding technique, the stator 4 having four (4) poles and six (6) slots is configured.

**[0056]** The periphery surface of such a stator core 74 contacts and is fixed to the internal wall of the shell 1A of the closed vessel 1. In this case, when a dimension of the area in the direction of the rotating shaft 6 in which the stator core 74 contacts the closed vessel 1 is H, and a dimension of the above stator core 74 in the direction the rotating shaft 6 is  $H_0$ ,  $H < H_0$  is configured. Furthermore, in the peripheral surface of the stator core 74 are formed a plurality of notches 76 (in an example, six (6)) with the circumference thereof notched in a chord shape, and these notches 76 are spaced from the internal wall of the shell 1A, wherein a path 77 for oil return is configured, as will be described later.

**[0057]** FIG. 3 is a longitudinally partial section side view of the rotor 5 shown in FIG. 1, and FIG. 4 is a plan view (in a situation before being inserted into the rotating shaft 6). In each drawing, a rotator core 26 has a plurality of steel sheets for a rotor 27 with such a shape shown in FIG. 5 stamped from a magnetic steel sheet with 0.3 to 0.7 mm of thickness to be laminated to caulk each other for integration (In addition, integration by welding instead of caulking is also acceptable.).

**[0058]** This steel sheet for a rotator 27 is stamped from the magnetic steel sheet so that salient poles 28 to 31 are formed that constructs such a quadrupole magnetic pole shown in FIG. 5, and 32 to 35 are concavities provided so that the salient poles are formed between each of the salient poles 28 to 31 and the other respectively. An outside diameter (diameter) D of apexes of the above salient poles 28 to 31 is, for example, 50 mm in the example of a compressor of a 15 frame. Furthermore, a predetermined range is obliquely and inwardly cut out from the outside surface of each of the salient poles 28 to 31 in a clockwise direction (a rotating direction of the rotator 5. In the example, a clockwise direction in FIG. 5) to form cut portions 36 to 39. In addition, When the rotator 5 is designed so as to rotate in counterclockwise direction, the opposite side to the clockwise direction are cut out to configure the cut portions 36 to 39. Namely, the opposite side to FIG. 4 and FIG. 5 is cut out.

**[0059]** 41 to 44, which are slots for press-fitting a magnetic substance 45 (permanent magnet) to be described later, correspond to each of salient poles 28 to 31, and are concentrically slotted in the periphery of the steel sheet for a rotator 27 along the axial direction of the rotating shaft 6. Moreover, a width d of a narrow path between each of slots 41 to 44 and a neighboring salient pole of the salient pole 28 to 31 is to be set at 0.3 mm to 1.0 mm (in the example, 0.5 mm).

**[0060]** Furthermore, 46, which is formed in the center of the steel sheet for a rotator 27, is a hole into which the rotating shaft 6 is shrink-fitted. Moreover, the rotator core 26 is formed by caulking each other for integration after laminating a plurality of steel sheets for a rotator 27. 47 to 50 are penetrated holes of which the shape is almost the same as that of holes into which rivets 51 to 54 for caulking to be described later are inserted, are correspondingly slotted inside each of the slots 41 to 44. 56 to 59, which are caulking portions for fastening each of steel sheets for a rotor 27 to the other, are formed between each of slots 41 to 44 and the other in the near concentricity with the penetrated holes 47 to 50. Furthermore, 61 to 64 are holes for forming an oil passage slotted inside the caulking portions 56 to 59.

**[0061]** By laminating a plurality of the steel sheets for a rotator 27 to caulk each other in the caulking portions 56 to 59 for integration, such rotator core 26 such as shown in the side view of FIG. 6 is formed. At this moment, the diameter of the rotator core 26 is the diameter D (50mm) of the foregoing steel sheet for a rotator 27, and the laminated dimension L in the direction of the rotating shaft 6 is set to be, for example, 40 mm. Herein, a ratio of the diameter D and the dimension L,  $L/D$ , is configured to be smaller than 1.1 and, in the example, is 0.8. Namely, the dimension L in the direction of the rotating shaft 6 is set to be smaller.

**[0062]** On the other hand, a magnetic substance 45 is constituted of, for example, a rare earth magnetic material

such as praseodymium magnetic material, a neodymium magnetic material with the surface thereof nickel-plated, or the like, of which the external shape is to be rectangular such as shown in FIG. 7. In addition, each of the slots 41 to 44 is to be sized so that this magnetic substance 45 is neatly press-fitted. The thickness  $t$  of the above magnetic substance 45 is sized to be, for example, 2.65 mm, and the dimension thereof in the direction of the rotating shaft 6 Hmg is sized to be 40 mm, which is the same as the foregoing dimension  $L$ . In addition, a ratio of the thickness  $t$  and the dimension Hmg,  $t/Hmg$ , is configured to be smaller than 0.1 (in the example, 0.08). Namely, in case that the dimension Hmg of the magnetic substance 45 in the direction of the rotating shaft 6 is Hmg, and the dimension of the stator core 74 in the direction of the rotating shaft 6 is  $H_o$ ,  $Hmg < H_o$  is configured. Moreover, 72 is a discus-shape plate for separating oil attached to the rotator 5, which is positioned above an end member 66, and 73 is a balancing weight attached between the plate 72 and the end member 66.

[0063] 66 and 67, which are flat-plate end members being attached to the upper end lower ends of the rotator core 26, are formed of nonmagnetic materials such as aluminum, a resin material and so forth in almost the same shape as that of the steel sheet for a rotator 27. In addition, the diameter of this end members 66 and 67 are to be almost the same as or a little smaller than the outer diameter  $D$  of the rotator core 26. Moreover, penetrated holes 81 to 84 are slotted at the positions that correspond to the penetrated holes 47 to 50 in end members 66 and 67. At the positions that correspond to the holes 59 and 61 to 64 are slotted holes 76 and 87 to 90.

[0064] Furthermore, after press-fitting the magnetic substance 45 into the slots 41 to 44 of the rotator core 26, the upper and lower end members 66 and 67 are set to clog the upper and lower end of slots 41 to 44. In this situation, the penetrated holes 47 to 50 and 81 to 84 penetrate the rotator core 26 and the end members 66 and 67 along the direction of the rotating shaft 6. Moreover, the holes 61 to 64 and 87 to 90 penetrate the rotator core 26 and the end members 66 and 67. Thereafter, the rivets 51 to 54 are sequentially inserted into each of the penetrated holes 47 to 50 and 81 to 84 to caulk the upper and lower ends thereof for an integrated configuration. In addition, 73 is a balancing weight, which is fixed to the rotator core 26 together with the upper end member 66 by the rivet 51.

[0065] In the stator core 74 is provided a notch 74A, and this notch 74 A has a predetermined dimension to be cut out in the circumferential direction of the rotating shaft 6 of the rotator 5 and simultaneously a predetermined depth to be cut out in the direction of the rotating shaft 6. In this case, when the length of the contact between the rotator core 74 and the internal wall of the shell 1A is  $H$  ( $H_1 + H_2$  in the drawing), and the laminated thickness of the stator core 74 (in this case, the dimension of the rotator 5 in the direction of the rotating shaft 6) is  $H_o$ , a ratio of the dimension  $H$  to the dimension  $H_o$  is configured to be  $0.2 \leq H/H_o \leq 0.8$ .

[0066] Namely, both sides  $H_1$  and  $H_2$  of the notch 74A provided in the stator core 74 in the circumferential direction of the rotating shaft 6 is caused to contact the internal wall of the shell 1A, and simultaneously the notch 74A is caused to be spaced from the internal wall of the shell 1A. Thereby, in the motor 2 (DC motor), the shake of the yoke of the above rotator 5 is difficult to transfer to the shell 1A due to a radial magnetic attraction/repulsion force of the rotator 5, as compared to a normal induction motor. Accordingly, the noise of the motor compressor C is possible to reduce.

[0067] On the other hand, the rotating compression element 3 comprises a first cylinder for a rotary 9 and a second cylinder for a rotary 10 separated by an intermediate parting stop 8. To each of the cylinders 9 and 10 is attached eccentrics 11 and 12 that are rotatably driven by the rotating shaft 6, and each eccentric of the eccentrics 11 and 12 are 180 degree out of phase from the other.

[0068] 13 and 14, which are a first roller and a second roller, rotate within the cylinders 9 and 10 respectively, and each thereof rotates within the cylinders 9 and 10 by the rotation of the eccentrics 11 and 12, respectively. 15 and 16 are a first frame and a second frame respectively, the first frame 15 causes compressed air to be formed between the parting stop 8 and it upon the cylinder 9 being closed, and the second frame 16 also causes compressed air to be formed between the parting stop 8 upon the cylinder 10 being closed. Moreover, the first frame 15 and the second frame 16 comprise bearings 17 and 18 respectively that rotatably and axially support the lower portion of the rotating shaft 6.

[0069] 19 and 20 are cap mufflers, which are attached so as to cover the first frame 15 and the second frame 16 respectively. In addition, the cylinder 9 and the cap muffler 19 are in communication by a communicating hole (not shown) provided in the first frame 15, and the cylinder 10 and the cap muffler 20 are also in communication by a communicating hole (not shown) provided in the second frame 16. Furthermore, in the present example, the cup muffler 20 facing the bottom surface of the closed vessel is in communication with the cup muffler 19 facing the top surface thereof via a penetrated hole 79 that penetrates the cylinders 9 and 10 and the intermediate parting stop 8.

[0070] 22 is a vent pipe provided on the top of the closed vessel 1, and 23 and 24, which are suction pipes, connect to the cylinders 9 and 10 respectively. Moreover, 25, which is a closed terminal, is for supplying a power from the external side of the closed vessel 1 to a stator winding 7 of the stator 4 (a lead wire that connects the closed terminal 25 and the stator winding 7 is not shown).

[0071] In such a configuration, when a power is applied to the stator winding 7 of the stator 4 of the motor 2, rotating magnetic field is formed to rotate the rotator 5. The rollers 13 and 14 within the cylinders 9 and 10 is eccentrically rotated via the rotating shaft 6 due to this rotation of the rotator 5, and suction gas sucked from the suction pipes 23

and 24 is compressed.

[0072] The compressed high-pressure gas is vented into the cap muffler 19 from the cylinder 9 via the continuous hole, and is vented into the upper side of the closed vessel 1 from the vent hole (not shown) formed in this cup muffler 19. On the other hand, from the cylinder 10, the compressed high-pressure gas is vented into the cup muffler 20 via the communication hole, enters the cup muffler 19 through a penetrated hole (not shown), and is vented similarly into the upper side of the closed vessel 1 from the vent hole.

[0073] The vented high-pressure gas passes through a gap provided within the stator 4 of the motor 2, a gap between the stator core 74 and the rotator 5, and the concavities 32, 33, 34 and 35 of the rotator core 26 to go up. Furthermore, the gas impinges upon a plate 72 and, by a centrifugal force, is directed toward the outside to go up, and is vented from a vent pipe 22.

[0074] Next, in FIG. 23 is shown a refrigerant circuit of a cooling apparatus using such a motor compressor C. The exit side of the motor compressor C is connected to a condenser 69, and the exit side of the condenser 69 (not shown) is connected to an expansion valve 70 that serves as a decompression apparatus via a fluid receptor and a fluid pipe solenoid-operated valve. The expansion valve 70 is connected to an evaporator 71, and at the exit side of the evaporator 71 is configured an annular refrigerant circuit connected to the suction side of the motor compressor C via an accumulator. High-temperature and high-pressure gas refrigerant vented from the motor compressor C radiates heat, is condensed and liquefied at the condenser 69. Moreover, after the above gas is decompressed at the expansion valve 70, it enters the evaporator 71, wherein a cycle process for taking heat to gasify is to be repeated.

[0075] A noise waveform of the above motor compressor C is shown in FIG. 9. It is seen from FIG. 9 that the noise within the audible sound band (500 Hz to 1.6 kHz), which is hatched, decreased. In addition, the motor compressor C uses a two (2) cylinder rotary compressor (Twin rotary) 700 w, refrigerant is a R401A, the motor 2 is a series motor, and a rare earth permanent magnet is used. Moreover, it operated at  $Ct/Et=43^{\circ}\text{C}/44^{\circ}\text{C}$  and 80 Hz. A microphone is spaced 1m from the motor compressor 2 in a horizontal position. This result is shown in table 1.

Table 1

H/Ho	1.0	0.75	0.5	0.375	0.25
Ho	40	40	40	40	40
H	40	30	20	15	10
SOUND PRESSRE LEVEL db(A)	63.5	62.5	61	60.5	60

[0076] It is seen from the above-mentioned table that the noise has been reduced.

[0077] Thus, the notch 74A is provided in the periphery surface of the stator core 74 that constructs the rotor 5 of the motor 2 (DC motor) used in the motor compressor C, the other than this notch 74 A is caused to contact the internal wall of the shell 1A, and therefore, in the motor 2 (DC motor) used in the motor compressor C, the yoke of the above rotator 5 is shaken due to a radial magnetic attraction/repulsion force of the rotator 5 as compared with a normal induction motor, but since the notch 74A is provided in the periphery surface of the stator core 74 that constructs the rotor 5 of the motor 2 used in the motor compressor to cause the other than the notch 74 A to contact the internal wall of the shell 1A, even though the yoke of the stator 4 is shaken, the vibration transfer to the shell 1A becomes possible to reduce. Accordingly, the noise of the motor compressor C can be drastically reduced.

[0078] In particular, in a rare earth permanent magnet motor with a high magnetic force and a magnetic-pole concentrated winding motor with less number of slots, even though a variation in magnetic flux is bigger as compared with a motor with much number of slots, since the notch 74A is provided in the periphery surface of the stator core 74 to cause the other than the notch to contact the internal wall of the shell 1A, a vibration transfer to shell 1A from the yoke of the stator 4 becomes possible to reduce. Similarly, this allows the noise of the motor compressor C to be drastically reduced.

[0079] Next, in FIG. 10 and FIG. 11 is shown one more motor compressor C. In this case, in the periphery surface of the stator core 74 is provided the notch 74 A with a predetermined dimension cut out in the circumferential direction of the rotating shaft 6 of the rotator 5, and simultaneously with a predetermined depth cut out in the direction of the rotating shaft 6. The above notch 74 A has a predetermined dimension to be cut out in the circumferential direction of the rotating shaft 6 from anyone of the upper side and the lower side of the periphery surface of the stator core 74, viewed from the center of the stator core 74 (the lower side in the drawings) and simultaneously a predetermined depth to be cut out in the direction of the rotating shaft 6. In this case, when the length of the contact of the stator core 74 and the internal wall of the shell 1A is H (H1 in the drawings), and the laminated thickness of the stator core 74 (in this case, the dimension of the rotator 5 in the direction of the rotating shaft 6) is Ho,  $0.2 \leq H/Ho \leq 0.8$  is to be set.

[0080] Namely, one part of the side of the notch 74 A provided in the circumferential direction of the rotating shaft 6 of the stator core 74 is caused to contact the internal wall of the shell 1A, and simultaneously the notch 74 A is caused

to be spaced from the internal wall of the shell 1A. In addition, FIG. 10 and FIG. 11 are similar to FIG. 1 and FIG. 2 except the stator core 74. Thereby, in the motor 2 (DC motor) as compared with a normal induction motor, the shake of the yoke of the above rotator 5 is difficult to transfer to the shell 1A due to a radial magnetic attraction/repulsion force of the rotator 5. Accordingly, it becomes possible to similarly reduce the noise of the motor compressor C as set forth above.

**[0081]** Next, in FIG. 12 and FIG. 13 is shown one more motor compressor C. In this case, in the periphery surface of the stator core 74 is provided the notch 74 A with a predetermined dimension cut out in the circumferential direction of the rotating shaft 6 of the rotator 5, and simultaneously with a predetermined depth cut out in the direction of the rotating shaft 6. The above notch 74A has a predetermined dimension to be cut out in the circumferential direction of the rotating shaft 6 from anyone of the upper side and the lower side of the periphery surface of the stator core 74, viewed from the center of the stator core 74 (the upper side in the drawings), and simultaneously a predetermined depth to be cut out in the direction of the rotating shaft 6. In this case, when the length of the contact of the stator core 74 and the internal wall of the shell 1A is H (H2 in the drawings), and the laminated thickness of the stator core 74 (in this case, the dimension of the rotator 5 in the direction of the rotating shaft 6) is  $H_0$ ,  $0.2 \leq H/H_0 \leq 0.8$  is to be set.

**[0082]** Namely, one part of the side H2 of the notch 74 A provided in the stator core 74 in the circumferential direction of the rotating shaft 6 is caused to contact the internal wall of the shell 1A, and simultaneously the notch 74 A is caused to be spaced from the internal wall of the shell 1A. In addition, FIG. 12 and FIG. 31 are similar to FIG. 1 and FIG. 2 except the stator core 74. Thereby, in the motor 2 (DC motor) as compared with a normal induction motor, the shake of the yoke of the above rotator 5 is difficult to transfer to the shell 1A due a radial magnetic attraction/repulsion force of the rotator 5, thus similarly enabling the reduction in the noise the motor compressor C as set forth above.

**[0083]** Next, in FIG. 14 and FIG. 15 is shown one more motor compressor C. In this case, in the periphery surface of the stator core 74 is provided the notch 74 A with a predetermined dimension cut out in the circumferential direction of the rotating shaft 6 of the rotator 5, and simultaneously with a predetermined depth cut out in the direction of the rotating shaft 6. In the above notch 74 A, are cut out several areas in the circumferential direction, and simultaneously a predetermined depth is cut out in the direction of the rotating shaft 6. In this case, when the length of the contact of the stator core 74 and the internal wall of the shell 1A is H ( $H_1 + H_2 + H_3$  in the drawings), the laminated thickness of the stator core 74 (in this case, the dimension in the direction of the rotating shaft 6 of the rotator 5) is  $H_0$ ,  $0.2 \leq H/H_0$  ( $H_1 + H_2 + H_3$ )  $\leq 0.8$  is to be set.

**[0084]** Namely, the other areas ( $H_1 + H_2 + H_3$  in the drawings) than the notches 74 A provided at two (2) locations in the circumferential direction of the rotating shaft 6 of the stator core 74 is caused to contact the internal wall of the shell 1A, and simultaneously the notch 74 A is caused to be spaced from the internal wall of the shell 1A. In addition, FIG. 14 and FIG. 15 are similar to FIG. 1 and FIG. 2 except the stator core 74. Thereby, in the motor 2 (DC motor) as compared with a normal induction motor, the shake of the yoke of the above rotator 5 is difficult to transfer to the shell 1A due to a radial magnetic attraction/repulsion force of the rotator 5, similarly enabling the reduction in the noise of the motor compressor C as set forth above.

**[0085]** Next, in FIG. 16 and FIG. 17 is shown one more motor compressor C. In this case, the laminated thickness of each of the magnetic substances 45 (permanent magnet) ... inserted into each of the slots 41, 42, 43 and 44 provided in the rotator 5 is caused to be set to be smaller than the laminated thickness of the stator core 74 (in this case, the dimension in the direction of the rotating shaft 6 of the rotator 5). Furthermore, each of the magnetic substances 45 (permanent magnet) ... inserted into each of the slots 41, 42, 43 and 44 is caused to be positioned at the center of the longitudinal direction of each of the slots 41, 42, 43 and 44. Moreover, in case that the laminated thickness of the magnetic substances 45 provided in the rotator 5 is  $H_{mg}$ , and that the laminated thickness of the stator core 74 is  $H_0$ , a ratio of the dimension  $H_{mg}$  to the dimension  $H_0$  is configured to be  $0.2 \leq H_{mg}/H_0 \leq 0.98$ . Namely, each of the magnetic substances 45 ... inserted into each of the slots 41, 42, 43 and 44 is to be shortened by the same dimension from each of both ends of the slots 41, 42, 43 and 44. In addition, FIG. 16 and FIG. 17 are similar to FIG. 1 and FIG. 2 except the magnetic substance 45. Thereby, in the motor 2 as compared with a normal induction motor, the shake of the yoke of the above rotator 5 is difficult to transfer to the shell 1A due to a radial magnetic attraction/repulsion force of the rotator 5, thus similarly enabling the reduction in the noise of the motor compressor C as set forth above.

**[0086]** FIG. 8 is a diagram illustrating a demagnetization curve of a ferrite magnet material and of a rare earth-based magnet material that are a permanent magnet that is used as a magnetic substance 45, in which the longitudinal axis indicates a magnetic flux density B and a lateral axis a coercive force  $H_c$ . In addition, in the same drawing in case of a general ferrite magnet material the curve is shown by a broken line, in case of a rare earth-based magnet material by a solid line, and the curve at +25°C is T1 and the curve at +150°C is T2 respectively. As apparent from FIG. 8, both of the residual magnetic flux density  $B_r$  and the coercive force  $H_c$  of the rare earth-based magnet material are big as compared with that of the ferrite magnet material, and a magnetic energy product is also very big. Accordingly, even though a magnet area is lessened, a necessary gap magnetic flux number can be maintained, thus being able to obtain a required output.

**[0087]** Namely, even though the laminated thickness of each of the magnetic substances 45 ... is made shorter than



the laminated thickness of the stator core 74, a required output is possible to obtain, and therefore, the shake force being applied to the teeth of the stator 4 is possible to distribute towards the direction (an arrow direction in the drawing) of a wider width ( $H_o$ ) of the rotator 4 rather than a width ( $H_{mg}$ ) of the magnetic substance 45 almost without the reduction in the output of the motor 2, thus being able to alleviate the vibration transfer to the shell 1A by a distribution of the vibration transfer. In addition, it has been determined from effectiveness of the motor 1 and the cost of the stator 4 that the minimum  $H_{mg}/H_o$  is set to be 0.2.

[0088] The waveform of the noise of this motor compressor C is shown in FIG. 18. The noise is reduced in the band hatched in the drawing, 00 Hz to 10 Hz (the audible sound band). In this drawing, SH indicates  $H_o$ . It is seen from this drawing that in case of the stator 4 width  $H_o=40$  mm and the magnetic substance 45 width  $H_{mg}=40$  mm, the noise is conventionally big, in case of the stator 4 width  $H_o=50$  mm and the magnetic substance 45 width  $H_{mg}=40$  mm, the noise has been reduced, and in case of the stator 4 width  $H_o=45$  mm and the magnetic substance 45 width  $H_{mg}=40$  mm, the noise is between that of the stator 4 width  $H_o=40$  mm and that of  $H_o=50$ . In addition, also in this case, the motor compressor C uses a twin rotary 700 W, the refrigerant is a R401A, the motor 2 is a series motor, and a rare earth permanent magnet is used. Moreover, it operated at  $Ct/Et=43^\circ\text{C}/44^\circ\text{C}$  and 80 Hz. A microphone is spaced 1m from the motor compressor 2 in a horizontal position. In addition, an explanation of FIG. 18 is shown in table 2, and the noise level is a value when  $H_{mg}/H$  varies.

Table 2

$H/H_o$	1.0	0.89	0.8	0.6	0.4
$H_o$	40	45	50	50	50
$H$	40	40	40	30	20
SOUND PRESSRE LEVEL db(A)	63.5	61.5	60.5	60	59.5

It is seen from the above-mentioned table that the noise has been reduced.

[0089] Next, one more motor compressor C is shown in FIG. 19 and FIG. 20. In this case, in the motor compressor C, the stator 4 with the notch 74A of FIG. 1 provided is used, and simultaneously the rotator 5 is provided in which the laminated thickness of each of the magnetic substances 45 ... inserted into each of the slots 41, 42, 43 and 44 of FIG. 16 is shorter than that of the stator core 74.

[0090] The above magnetic substance 45 is configured so that a ratio of the diameter  $D$  and the dimension  $L$  in the direction of the rotating shaft 6 of the rotator core 26,  $L/D$ , is set to be smaller than 1.1, and simultaneously a ratio of the thickness  $t$  and the laminated thickness  $H_{mg}$  in the direction of the rotating shaft of the magnetic substance 45,  $t/H_{mg}$ , is set to be smaller than 0.1. Namely, it allows the vibration of the yoke of the rotator 4 to be distributed to reduce the vibration of the shell 1A that the magnetic substance 45 is constituted of the rare earth-based magnet material, and that, simultaneously, in case that the diameter of the rotator core 26 of the rotator 5 is  $D$ , the dimension of the above rotator core 26 in the direction of the rotating shaft 6 is  $L$ , and the thickness of the magnetic substance 45 is  $t$ , a ratio of the dimension  $L$  to the dimension  $D$  is set at  $L/D < 1.1$  and a ratio of the dimension  $t$  to the dimension  $H_{mg}$  is set at  $t/H_{mg} < 0.1$ , and simultaneously, it allows the vibration of the yoke of the stator 4 to be furthermore distributed to reduce the vibration of the shell that a ratio of the thickness dimension  $t$  and the laminated thickness  $H_{mg}$  in the direction of the rotating shaft 6 of the magnetic substance 45,  $t/H_{mg}$ , is set to be smaller than 0.1. In addition, FIG. 19 and FIG. 20 are similar to FIG. 1 and FIG. 2 except the stator core 74 and the magnetic substance 45. Even though the yoke of the stator 4 is shaken, this allows the shake force being applied to the teeth of the stator 4 to be distributed to drastically reduce the vibration transfer to the shell 1A. Accordingly, it becomes possible to drastically reduce the noise that is generated by the cooling apparatus provided in a air-conditioner, a cooling warehouse, a refrigerator, a showcase, and the like.

[0091] In accordance with the present invention set for in details above, the motor element is constituted of the stator having the stator core that contacts and is fixed to the internal wall of the container, and the rotator having the magnetic substance, which is attached to the rotating shaft and rotatably supported in the inside of the stator, and simultaneously, in case that the dimension of the area in which the stator core contacts the closed vessel is  $H$ , the dimension of the above stator core in the direction of the rotating shaft is  $H_o$ , is configured to be  $H < H_o$ , and therefore, the transfer of the vibration to the shell from the stator core can be lessened. Even though the yoke of the stator 4 is shaken, this enables the reduction of the vibration transfer to the teeth. Accordingly, it becomes possible to drastically reduce the noise of the motor compressor.

[0092] Furthermore, in accordance with the present invention, the motor element is constituted of the stator having the stator core that contacts and is fixed to the internal wall of the container, and the rotator having the magnetic substance, which is attached to the rotating shaft and rotatably supported in the inside of the stator, and simultaneously, in case that the dimension of the magnetic substance in the direction of the rotating shaft is  $H_{mg}$ , the dimension of the

above stator core in the direction of the rotating shaft is  $H_o$ , is configured to be  $H_{mg} < H_o$ , and therefore, a magnetic force of the magnetic substance in the direction of the rotating shaft of the stator core is possible to distribute. This allows the vibration of the rotator due to the magnetic force to be mainly concentrated toward the direction of the rotating shaft, thus reducing the vibration being applied to the shell. Accordingly, it becomes possible to drastically reduce the noise of the motor compressor.

[0093] Furthermore, in accordance with the present invention, the motor element is constituted of the stator having the stator core that contacts and is fixed to the internal wall of the container, and the rotator having the magnetic substance, which is attached to the rotating shaft and rotatably supported in the inside of the stator, and simultaneously, in case that the dimension of the area in which the stator core contacts the closed vessel is  $H$ , the dimension of the above stator core in the direction of the rotating shaft is  $H_o$ , and the dimension of the magnetic substance in the direction of the rotating shaft is  $H_{mg}$ , the motor element is configured to be  $H < H_o$  and  $H_{mg} < H_o$ , and therefore, the transfer of the vibration to the shell from the stator can be lessened, and yet, the magnetic force of the magnetic substance in the direction of the rotating shaft of the stator core is possible to distribute. Accordingly, it becomes possible to drastically reduce the noise of the motor compressor.

[0094] Furthermore, in accordance with the present invention, in addition to the first or the third invention, since a ratio of the dimension  $H$  to the dimension  $H_o$  is set to be  $0.2 \leq H/H_o \leq 0.8$ , as compared with a normal induction motor, the shake of the yoke of the rotator due to the a radial magnetic attraction/repulsion force of the rotator is difficult to transfer to the shell. Accordingly, it becomes possible to drastically reduce the noise of the motor compressor.

[0095] Furthermore, in accordance with the present invention, in addition to the second or the third invention, since a ratio of the dimension  $H_{mg}$  to the dimension  $H_o$  is set to be  $0.2 \leq H_{mg} / H_o \leq 0.98$ , and therefore, the shake force being applied to the teeth of the stator is possible to distribute. This allows the transfer of the vibration to the shell to decrease. Accordingly, while preventing the decrease in effectiveness of the motor and a cost-up of the stator, the vibration of the yoke of the stator that is shaken can be distributed, thus drastically reducing the noise of the motor compressor.

[0096] Furthermore, in accordance with the present invention, in addition to these, the magnetic substance is constituted of the rare earth-based magnet material, and simultaneously in case that the diameter of the rotator core of the rotator is  $D$ , the dimension of the above rotator core in the direction of the rotating shaft is  $L$ , and the thickness of the magnetic substance is  $t$ , a ratio of the dimension  $L$  to the dimension  $D$  is set to be  $L/D < 1.1$ , and a ratio of the dimension  $t$  to the dimension  $H_{mg}$  is set to be  $t/H_{mg} < 0.1$ , and therefore, it allows the dimension of the rotator core to be reduced while keeping a required motor output and simultaneously allows the vibration being generated by deflection of the rotator to be distributed to reduce the vibration of the shell that a ratio of the diameter  $D$  and the dimension  $L$  in the direction of the rotating shaft of the rotator core,  $L/D$ , is set to be smaller than 0.1, as compared with the case in which such ferrite magnet material as used conventionally is employed. Moreover, it allows the vibration being generated by deflection of the rotator to be furthermore distributed to reduce the vibration of the shell that a ratio of the thickness  $t$  and the laminated thickness  $H_{mg}$  in the direction of the rotating shaft of the magnetic substance,  $t/H_{mg}$ , is set to be smaller than 0.1, thus enhancing an effect of a drastic reduction in the noise. This allows the noise of the motor compressor to be drastically reduced, while preventing the decrease in effectiveness of the motor and a cost-up of the stator. Accordingly, it becomes possible to drastically enhance a practical effect of the motor compressor.

[0097] In particular, since a ratio of the diameter  $D$  and the dimension  $L$  in the direction of the rotating shaft of the rotator core,  $L/D$ , is set to be smaller than 1.1 to exclusively apply the dimension reduction of the rotator core to the dimension  $L$  in the direction of the rotating shaft, the vibration being generated by deflection of the rotator can be reduced without any alteration to a production equipment and the like caused by any change in the diameter of the rotator core or in the outer diameter of the closed vessel of the compressor.

[0098] Yet furthermore, since a refrigerant circuit is constituted of the motor compressor of the present invention, and a condenser, a decompression apparatus and an evaporator, it becomes possible to drastically reduce the noise of a cooling apparatus provided in a air-conditioner, a cooling warehouse, a refrigerator, a showcase, and the like. Accordingly, it is to be realized that a preferred cooling apparatus for a noise environment can be provided.

## Claims

1. A motor compressor comprising a motor element and a compression element which is driven by a rotating shaft connected to the motor element in a closed vessel, wherein  
the motor element is constituted of a stator having a stator core that contacts and is fixed to the inside wall of the closed vessel, and a rotator having a magnetic substance which is attached to a rotating shaft and rotatably supported in the inside of the stator; and  $H < H_o$  is satisfied wherein  $H$  is a dimension in a rotating shaft direction of an area in which the stator core contacts the closed vessel, and  $H_o$  is a dimension in the rotating shaft direction of the above stator core.

2. A motor compressor containing a motor element and a compression element which is driven by a rotating shaft connected to the motor element in a closed vessel, wherein  
the motor element is constituted of a stator having a stator core that contacts and is fixed to an internal wall of the closed vessel, and a rotator having a magnetic substance which is attached to the rotating shaft and rotatably supported in the inside of the stator; and  $H_{mg} < H_o$  is satisfied wherein  $H_{mg}$  is a dimension in a rotating shaft direction of the magnetic substance and  $H_o$  is a dimension in a rotating shaft direction of the stator core.
3. A motor compressor comprising a motor element and a compression element which is driven by a rotating shaft connected to the motor element in a closed vessel, wherein  
the motor element is constituted of a stator having a stator core that contacts and is fixed to an internal wall of the closed vessel, and a rotator having a magnetic substance which is attached to the rotating shaft and rotatably supported in the inside of the stator; and  $H < H_o$  and  $H_{mg} < H_o$  are satisfied wherein  $H$  is a dimension in a rotating shaft direction of an area in which the stator core contacts the closed vessel,  $H_o$  is a dimension in the rotating shaft direction of the above stator core, and  $H_{mg}$  is a dimension in a rotating shaft direction of the magnetic substance.
4. The motor compressor according to claim 1 or 3, wherein a ratio of the dimension  $H$  to the dimension  $H_o$  is set to be  $0.2 \leq H / H_o \leq 0.8$ .
5. The motor compressor according to claim 2 or 3, wherein a ratio of the dimension  $H_{mg}$  to the dimension  $H_o$  is set to be  $0.2 \leq H_{mg} / H_o \leq 0.98$ .
6. The motor compressor according to claim 1, claim 2, claim 3, claim 4 or claim 5, wherein the magnetic substance is constituted of a rare earth-based magnet material; and a ratio of  $L$  to  $D$ ,  $L/D < 1.1$  is satisfied wherein  $L$  is a dimension in a rotating shaft direction of the above rotor core and  $D$  is a diameter of the rotator core of the rotator, and a ratio of  $t$  to the dimension  $H_{mg}$ ,  $t/H_{mg} < 0.1$  is satisfied wherein  $t$  is a thickness dimension of the magnetic substance.
7. A refrigerating apparatus in which a refrigerant circuit is constituted of the motor compressor according to claim 1, claim 2, claim 3, claim 4, claim 5 or claim 6, a condenser, a decompression apparatus and an evaporator.

FIG.1

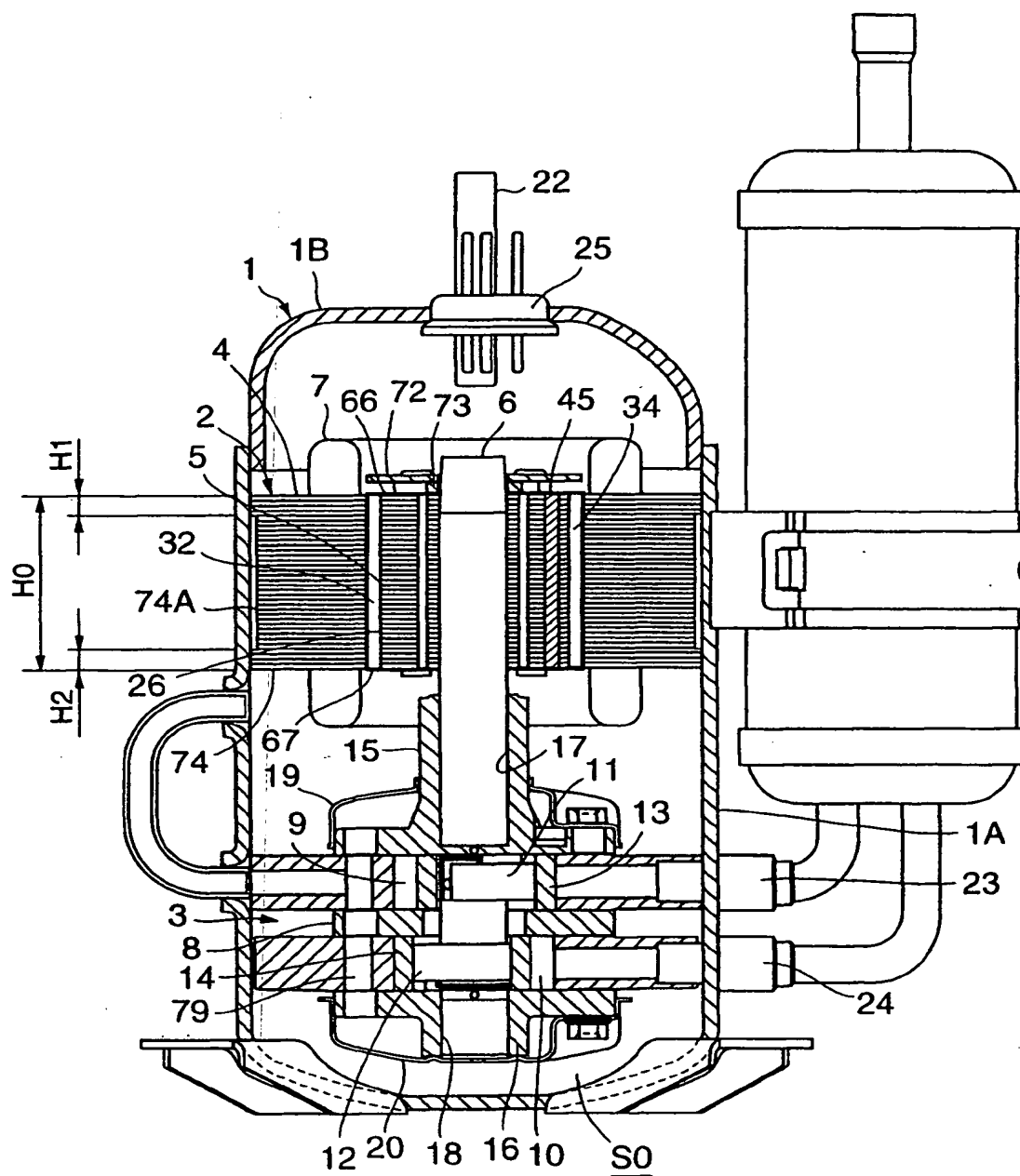


FIG.2

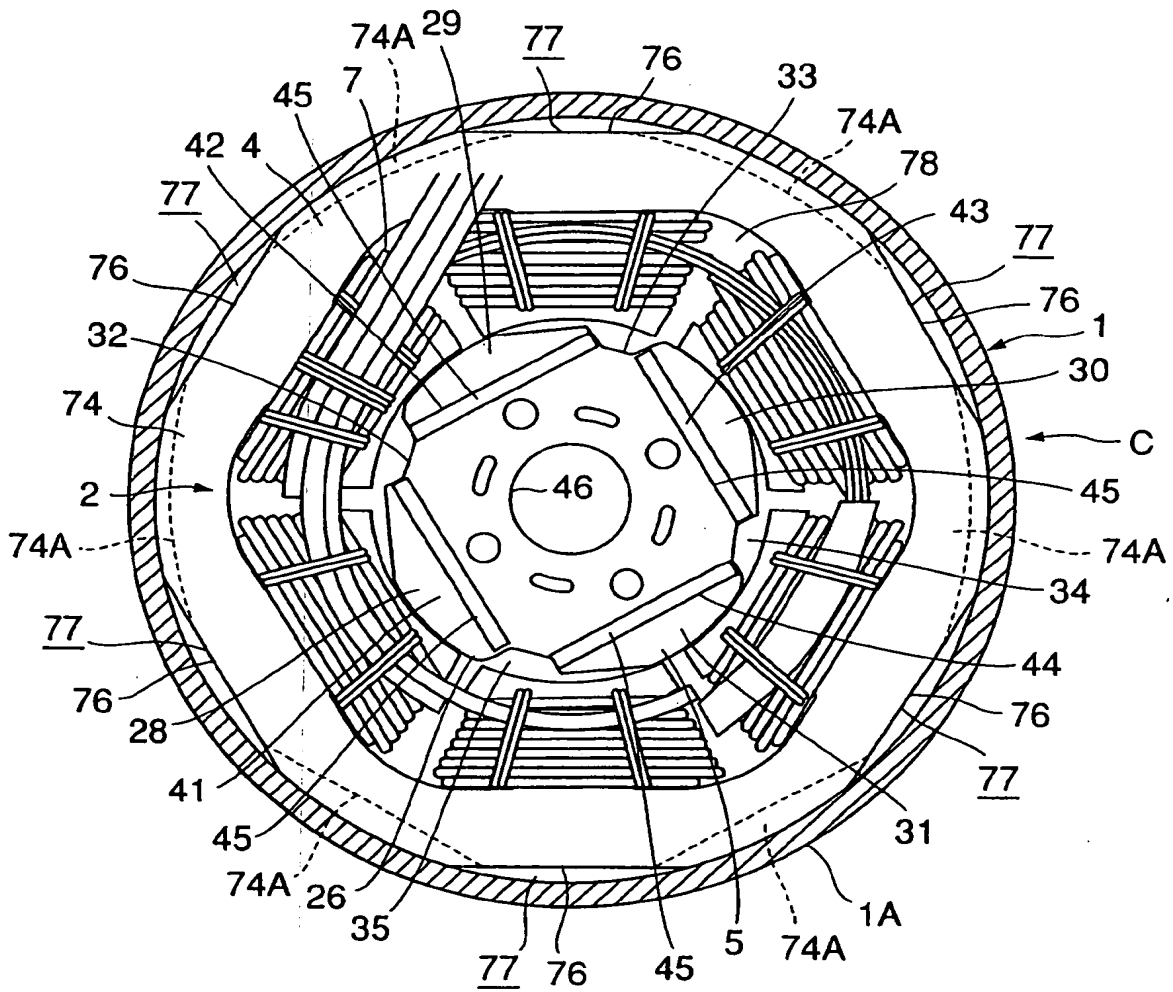


FIG.3

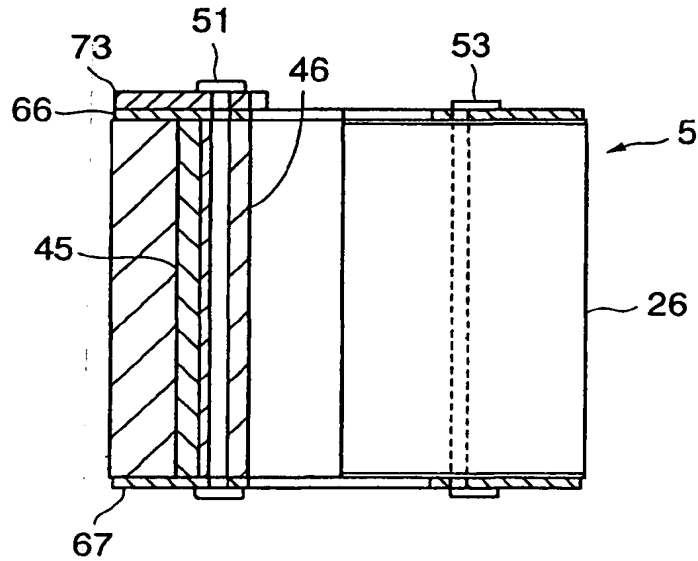


FIG.4

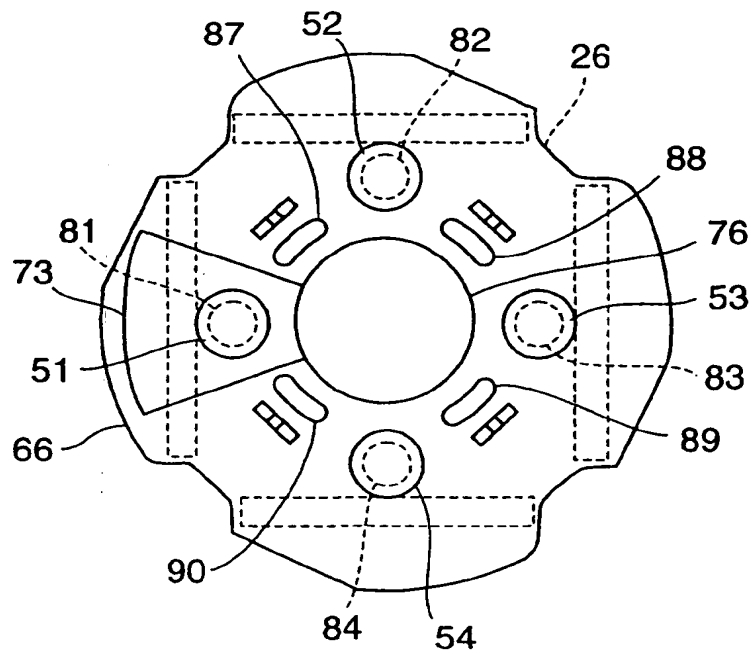


FIG.5

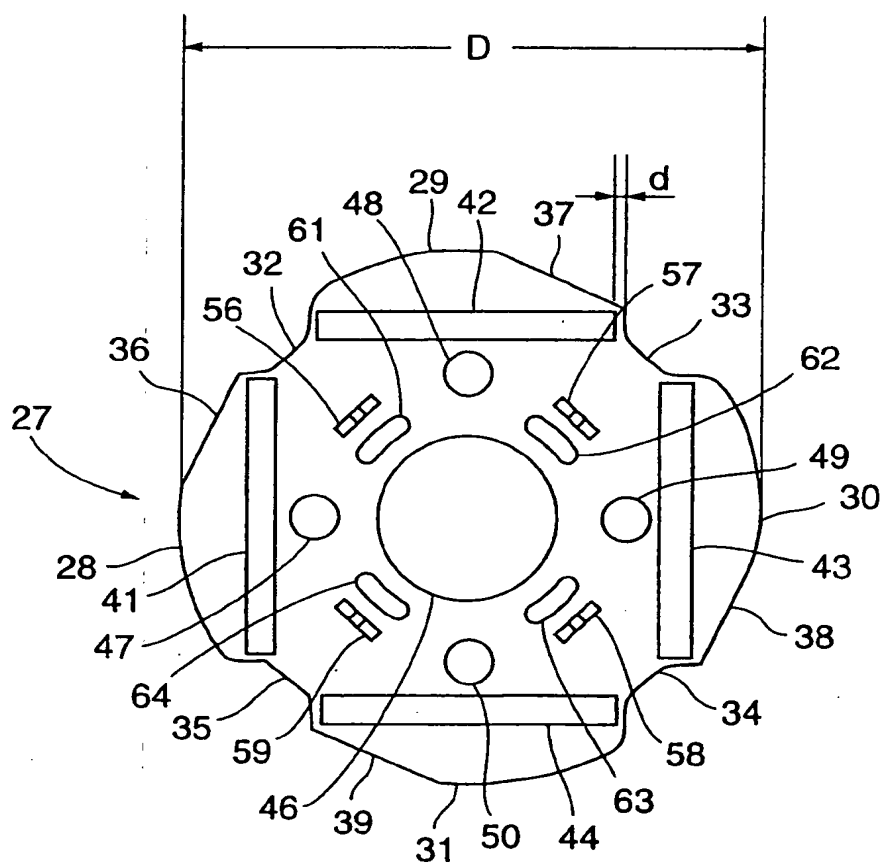


FIG.6

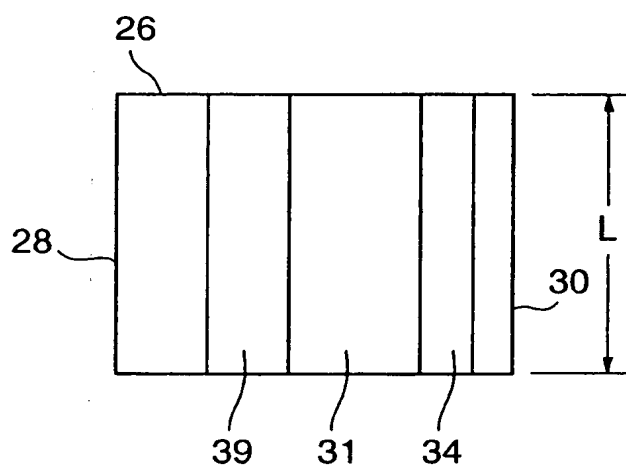


FIG.7

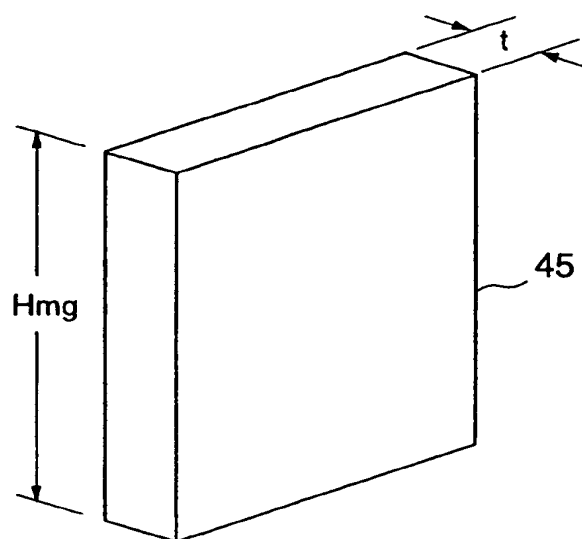
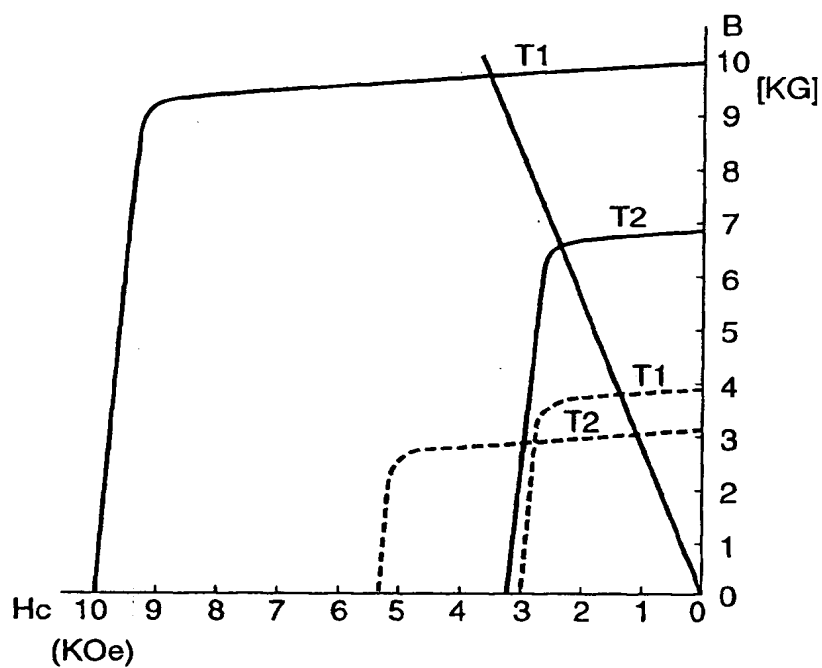




FIG.8



**FIG. 9**

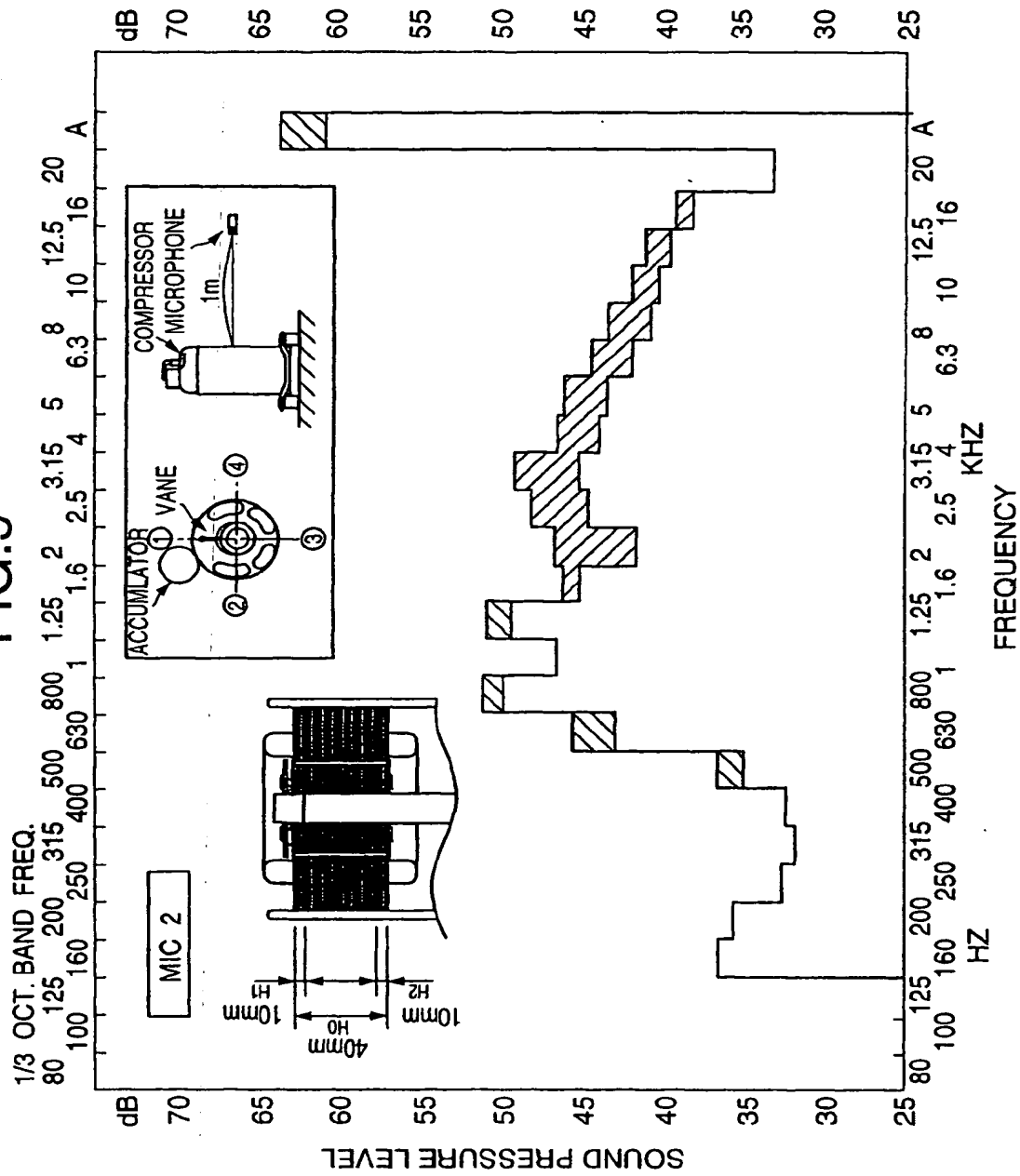


FIG.10

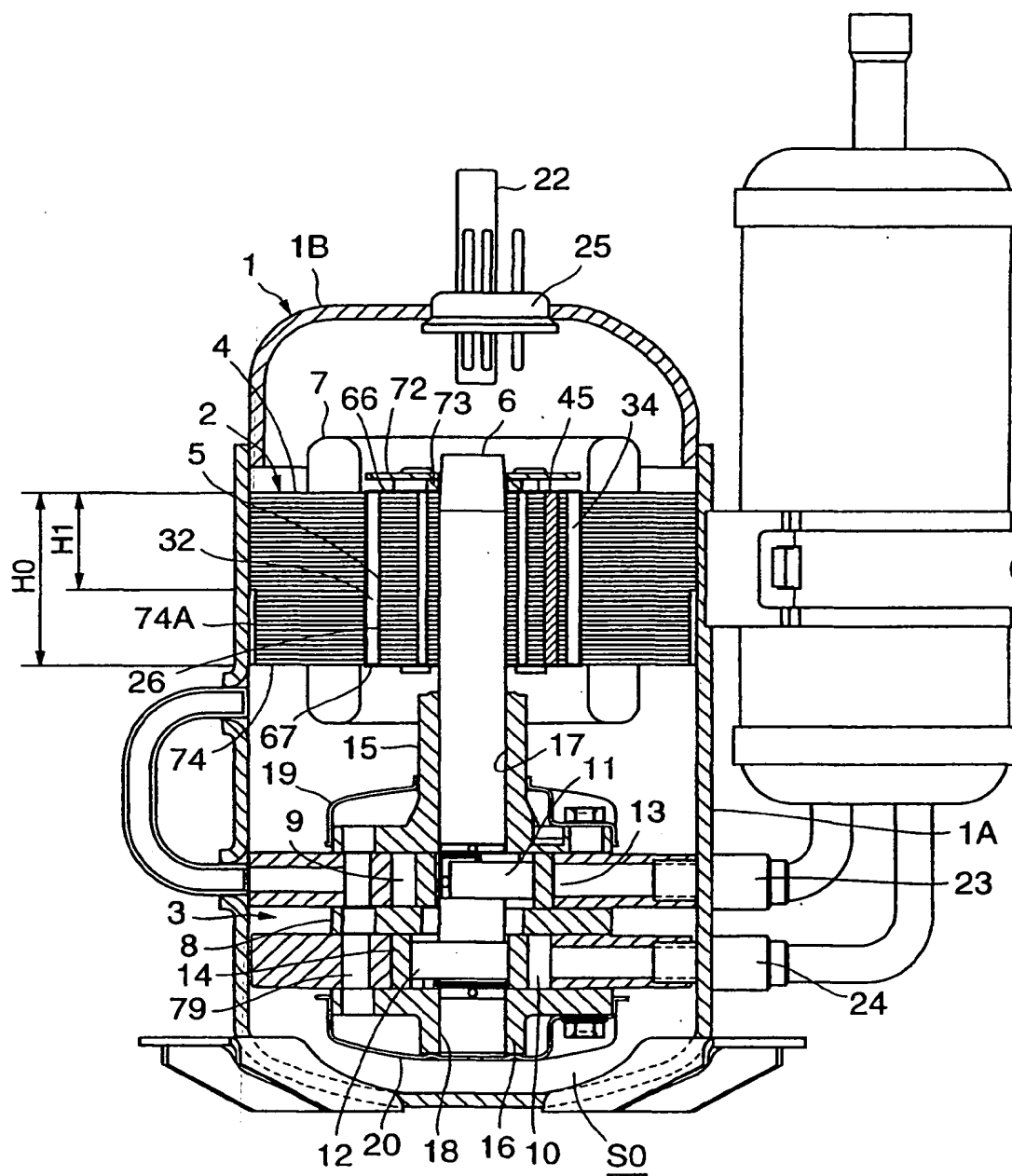


FIG.11

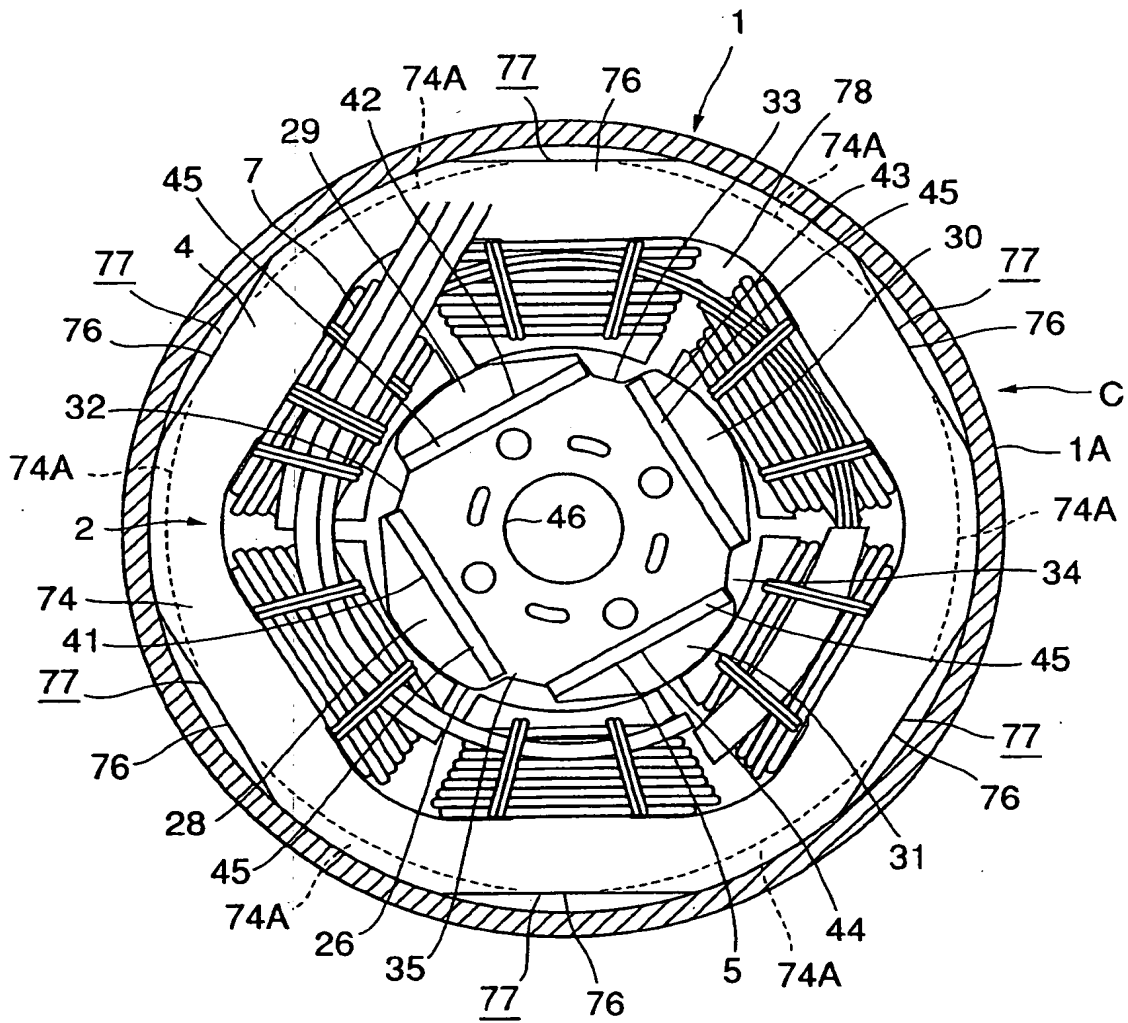


FIG.12

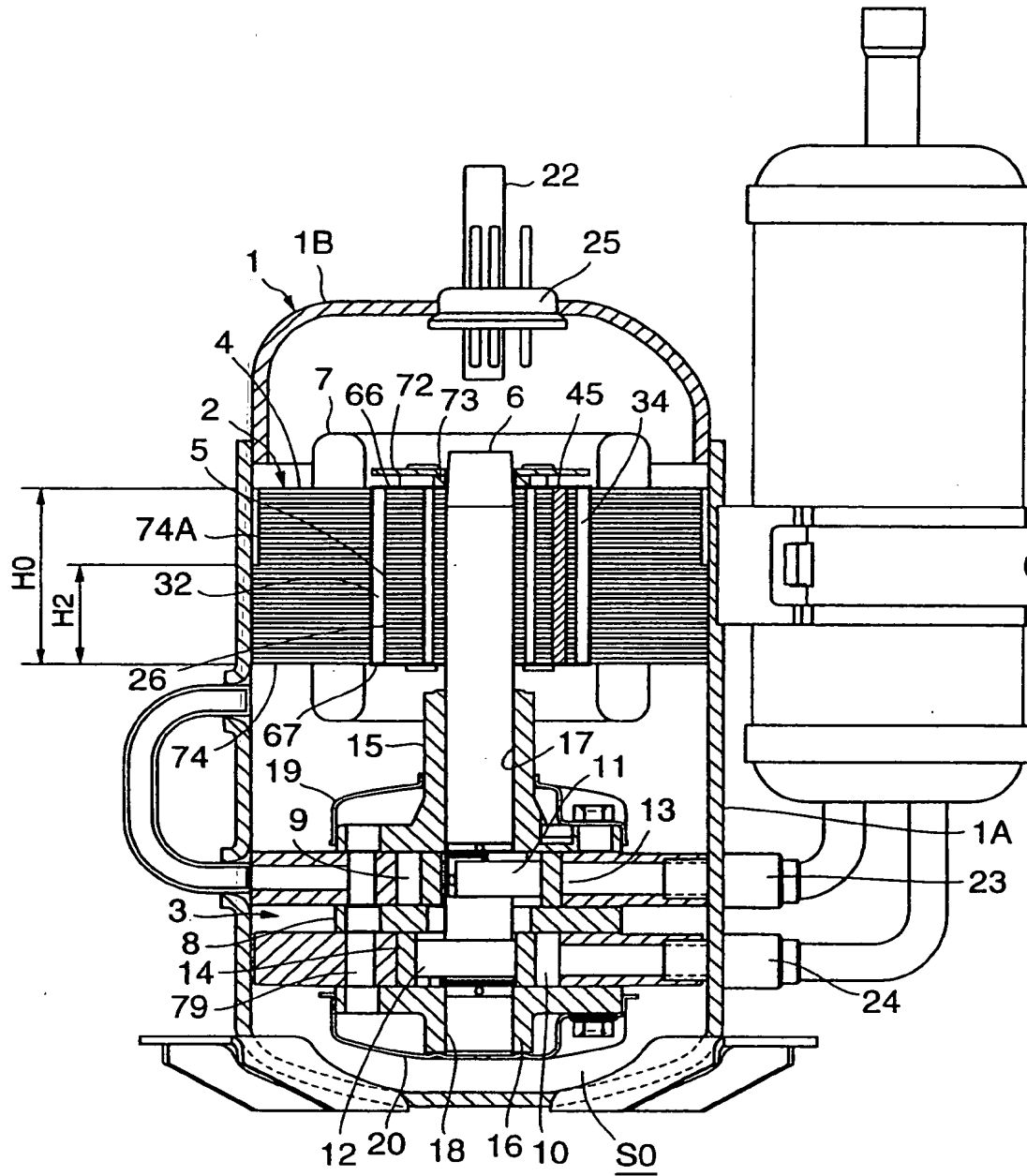


FIG.13

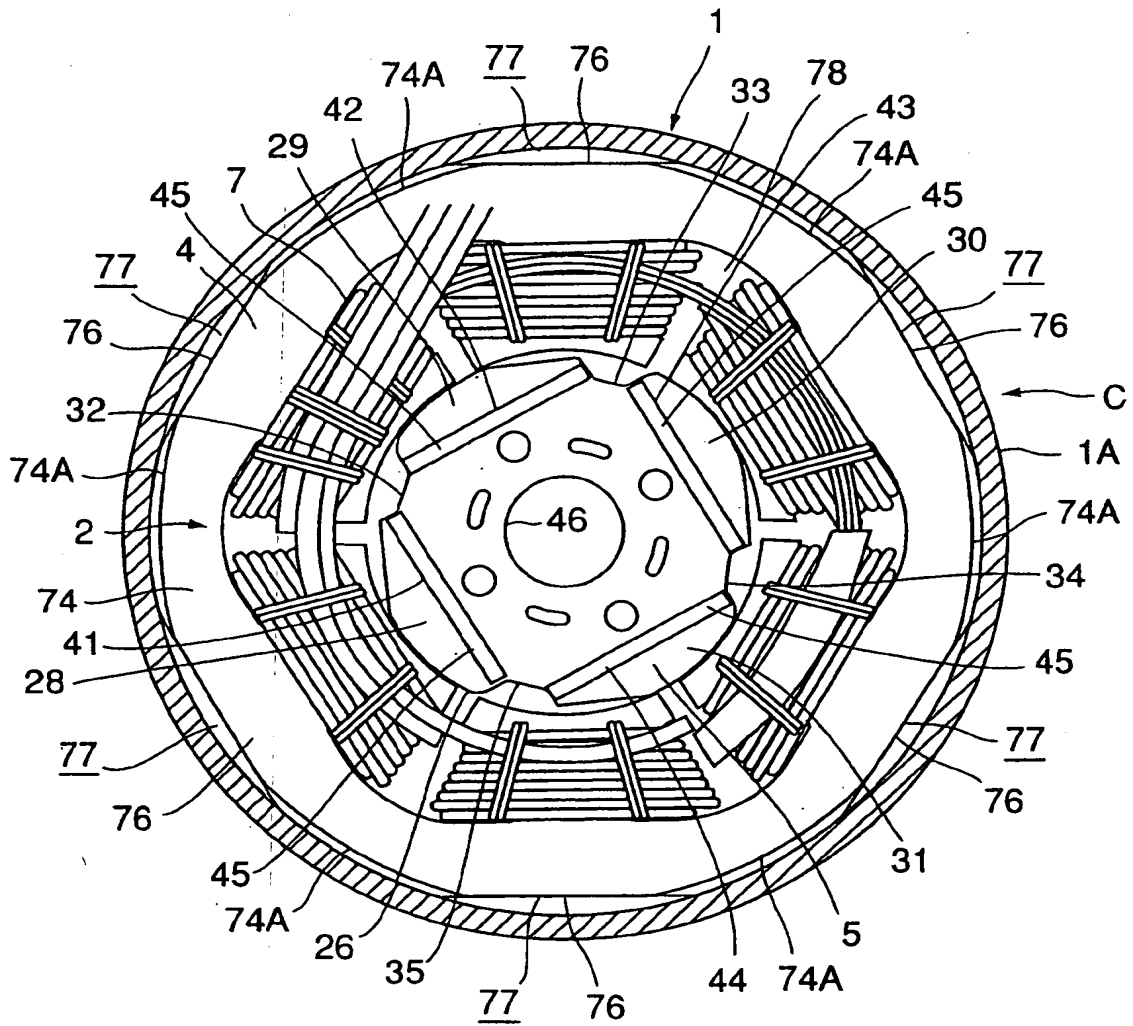


FIG.14

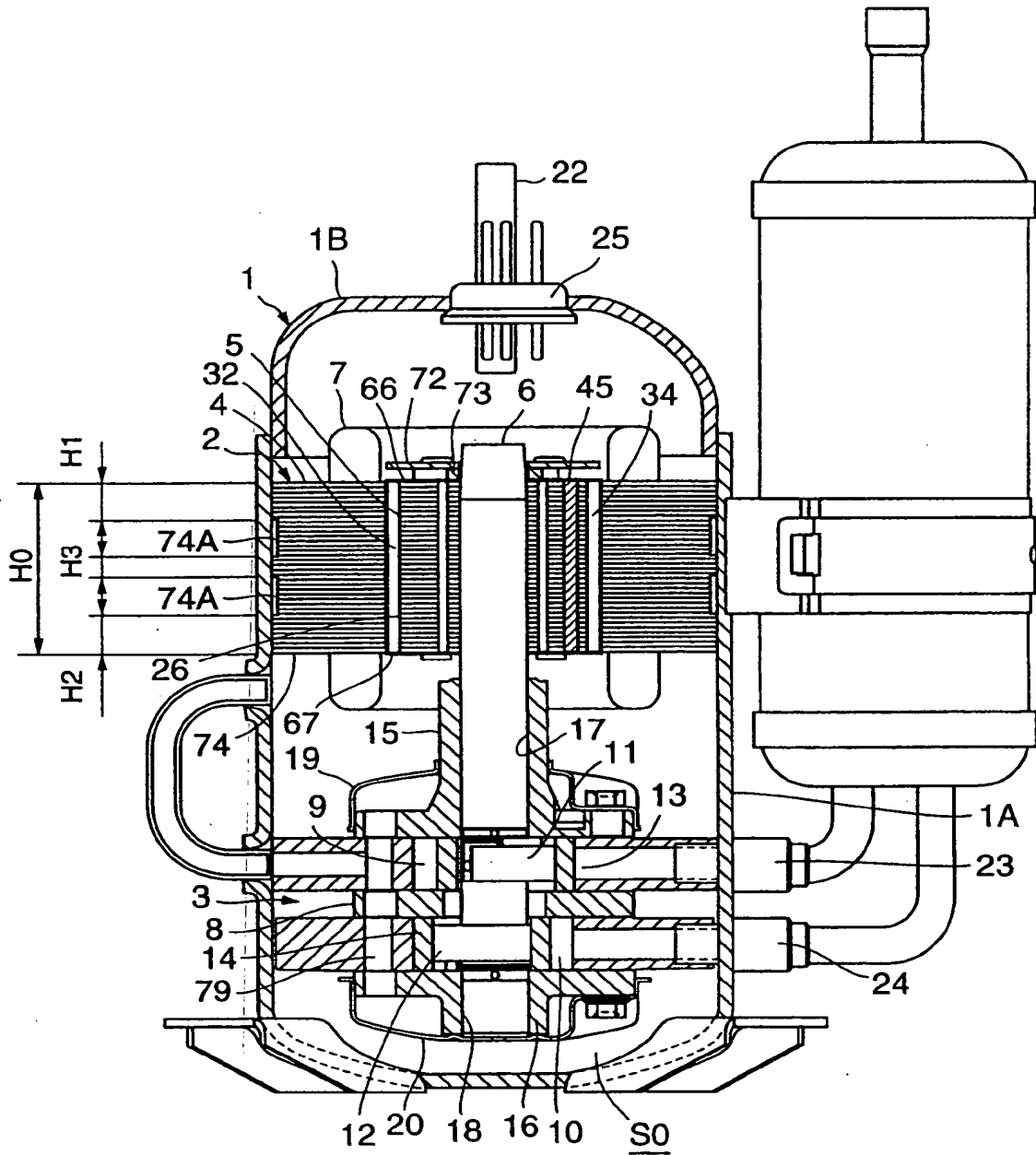


FIG.15

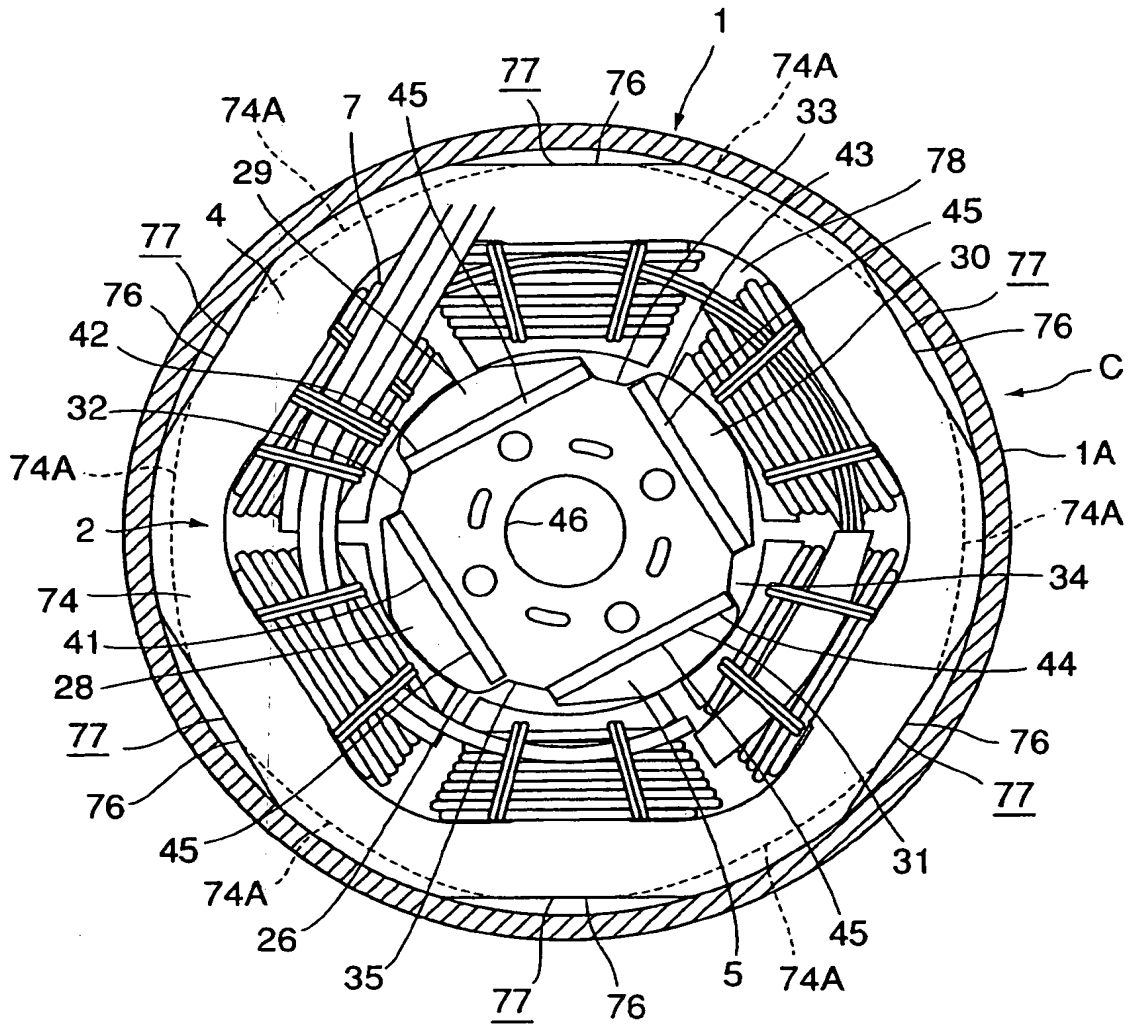




FIG.16

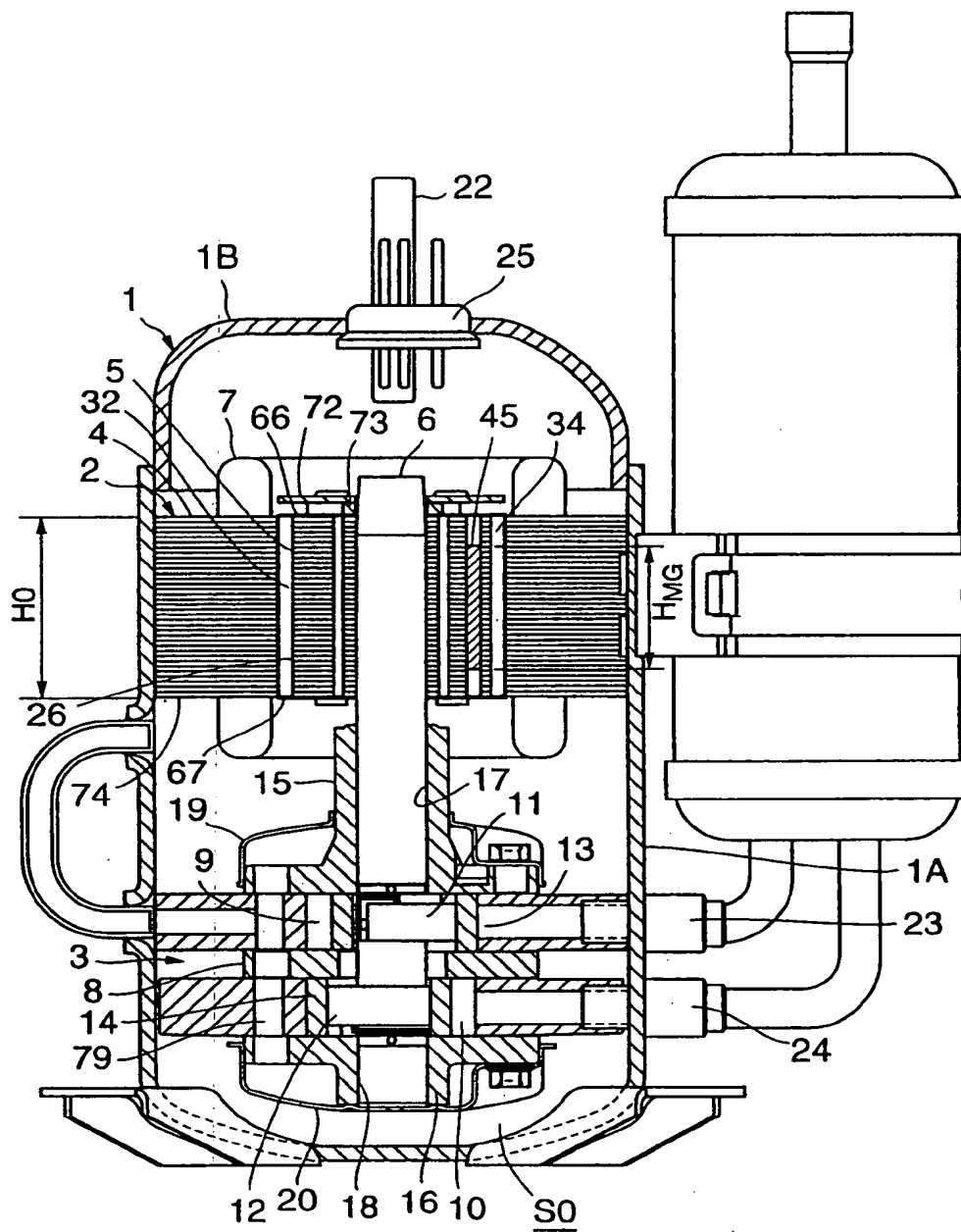
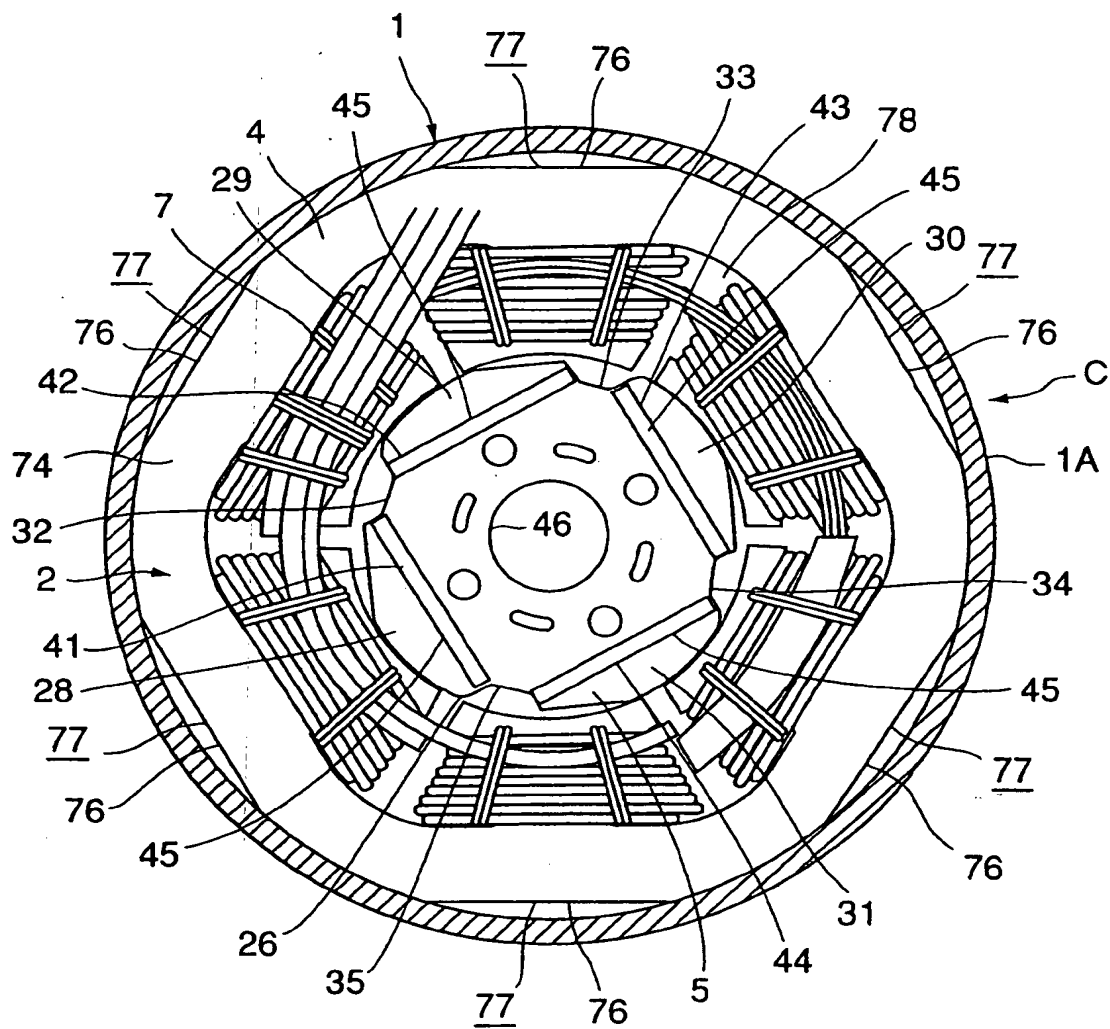


FIG.17



**FIG. 18**

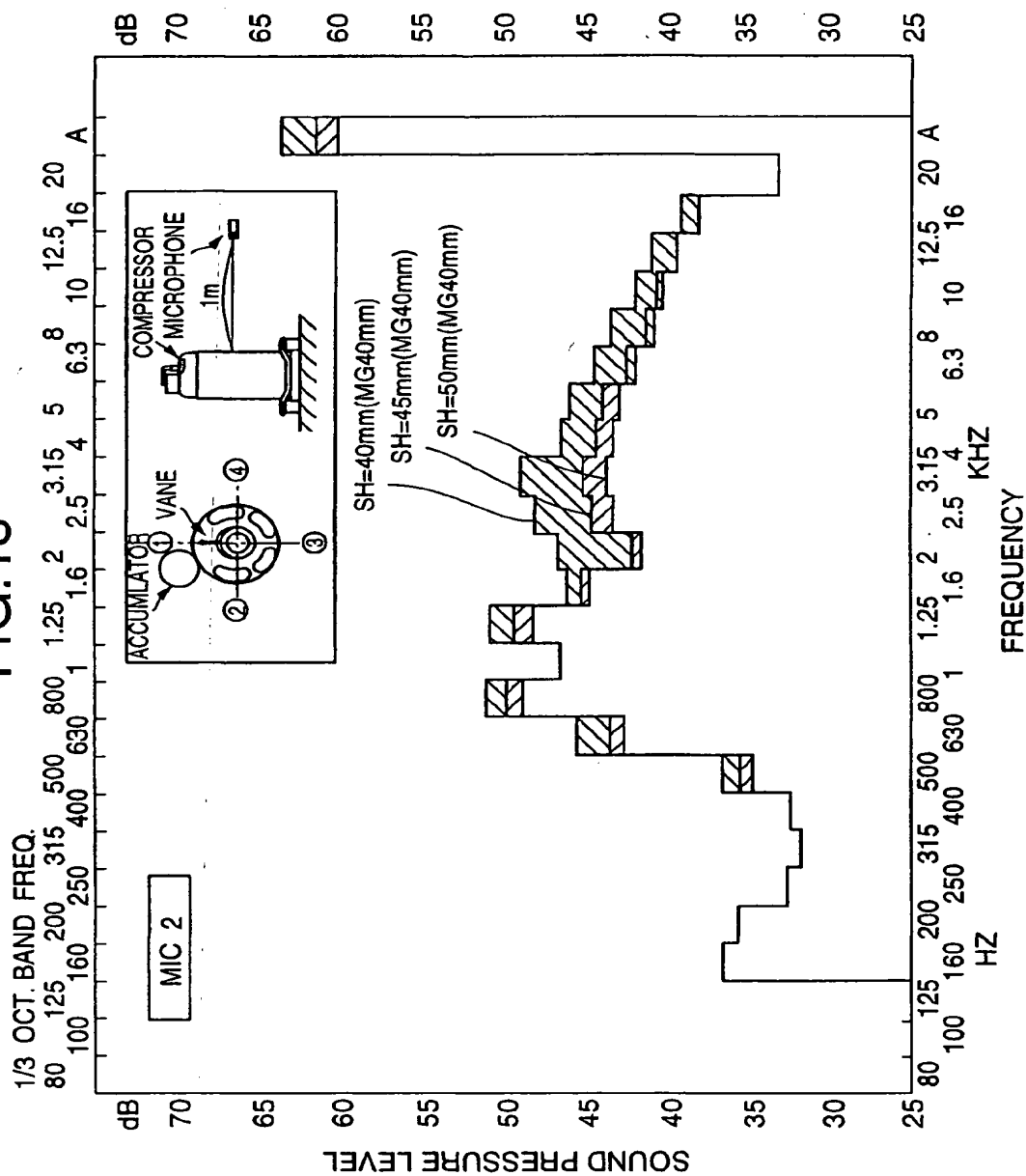


FIG.19

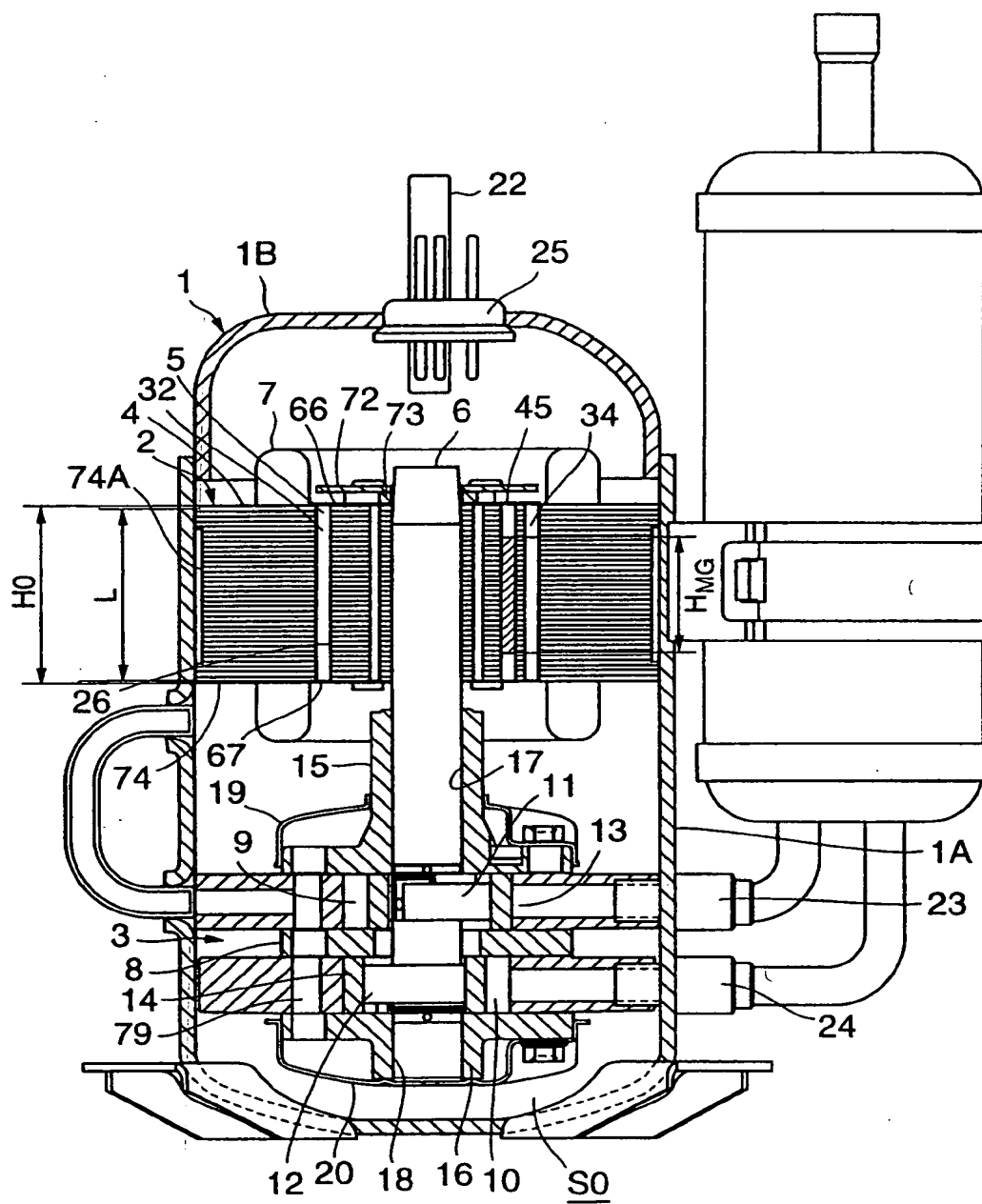


FIG.20

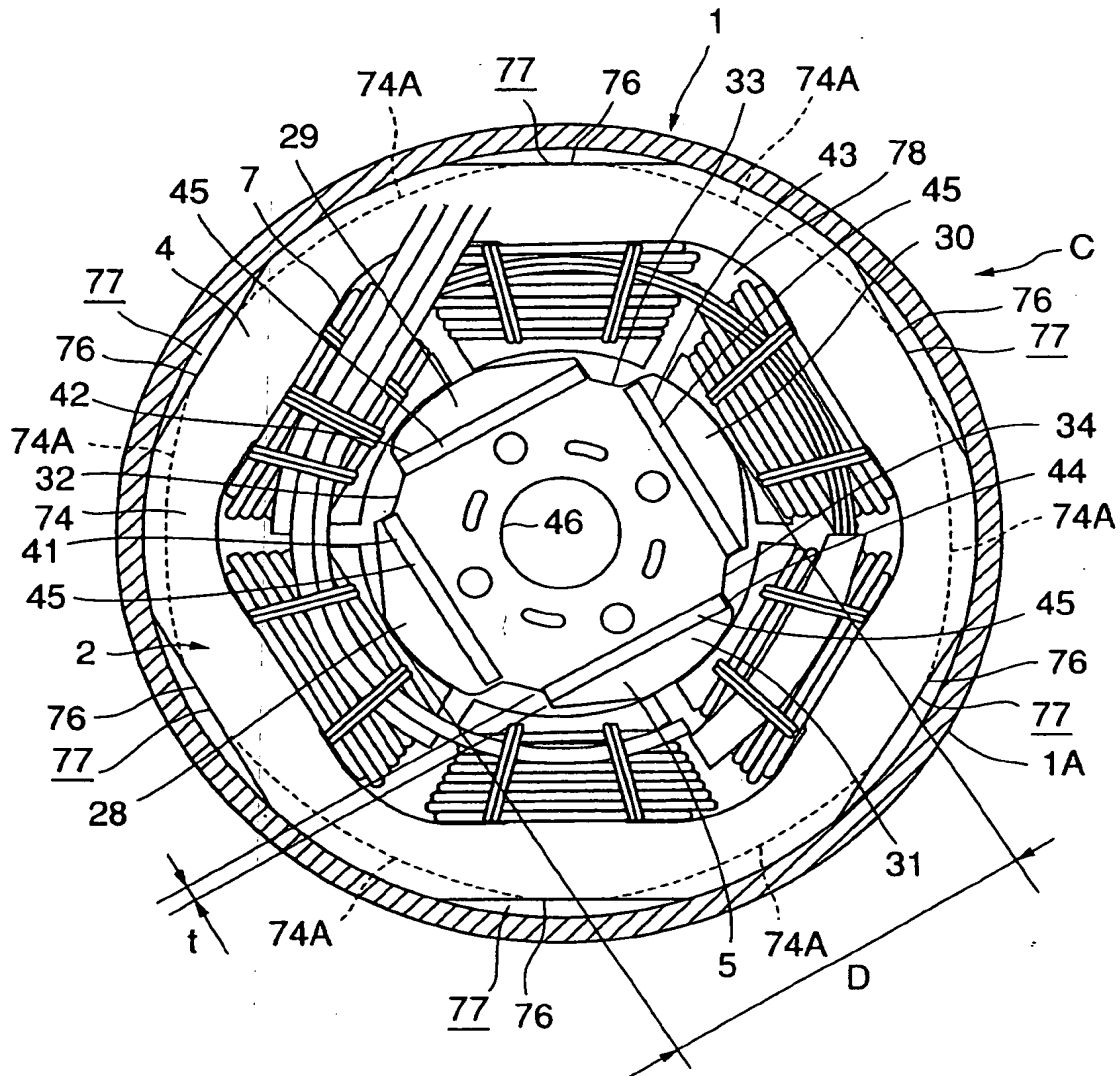


FIG.21

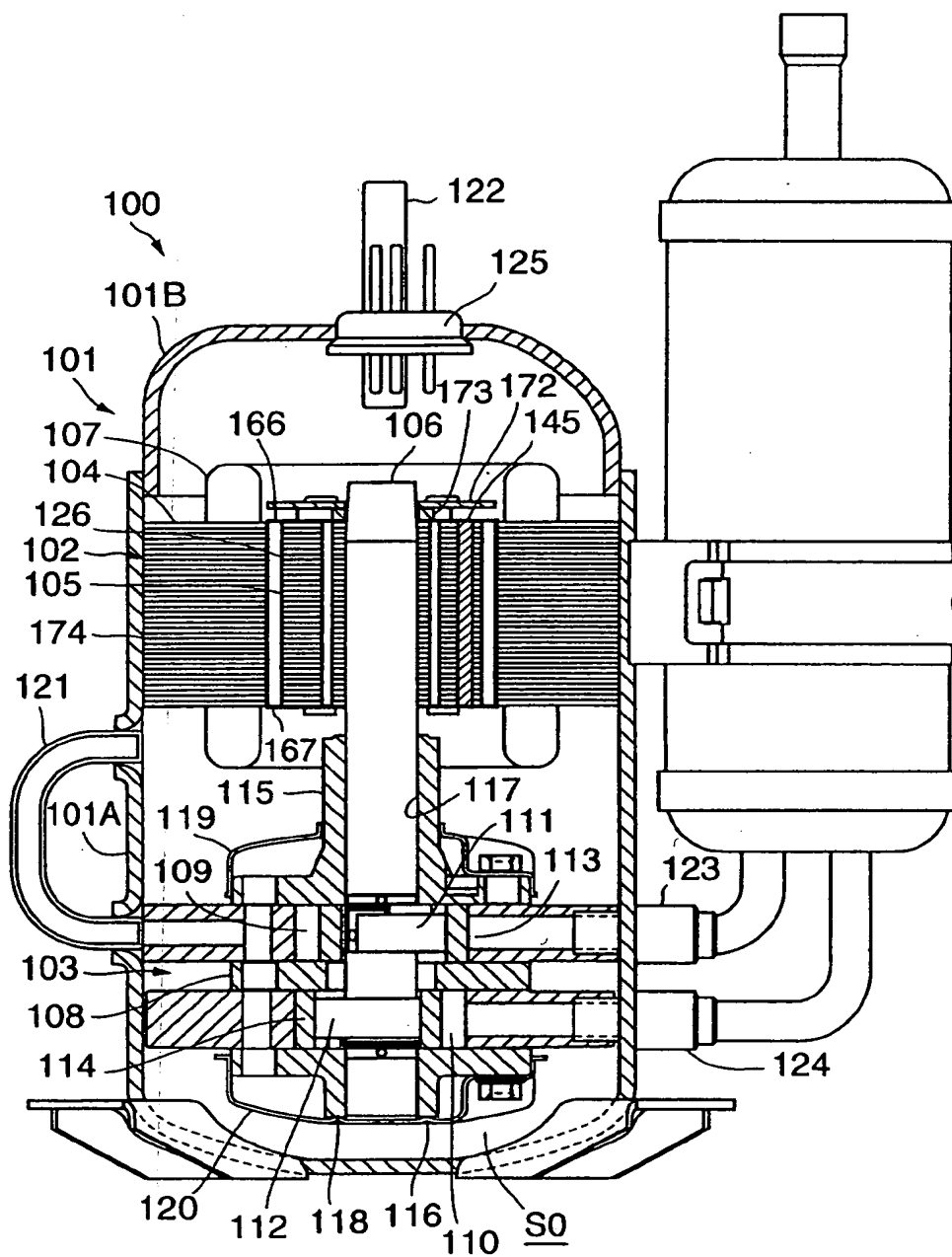


FIG.22

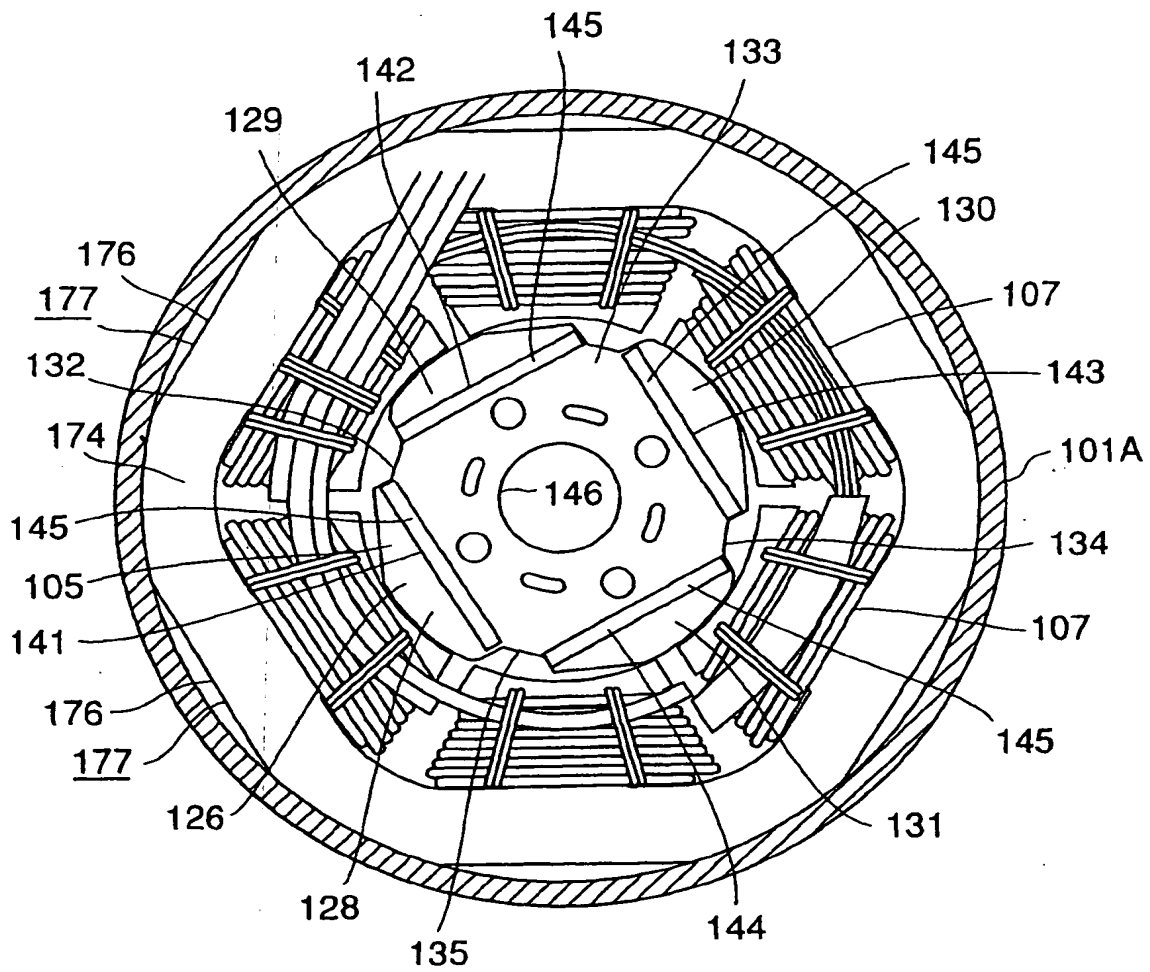
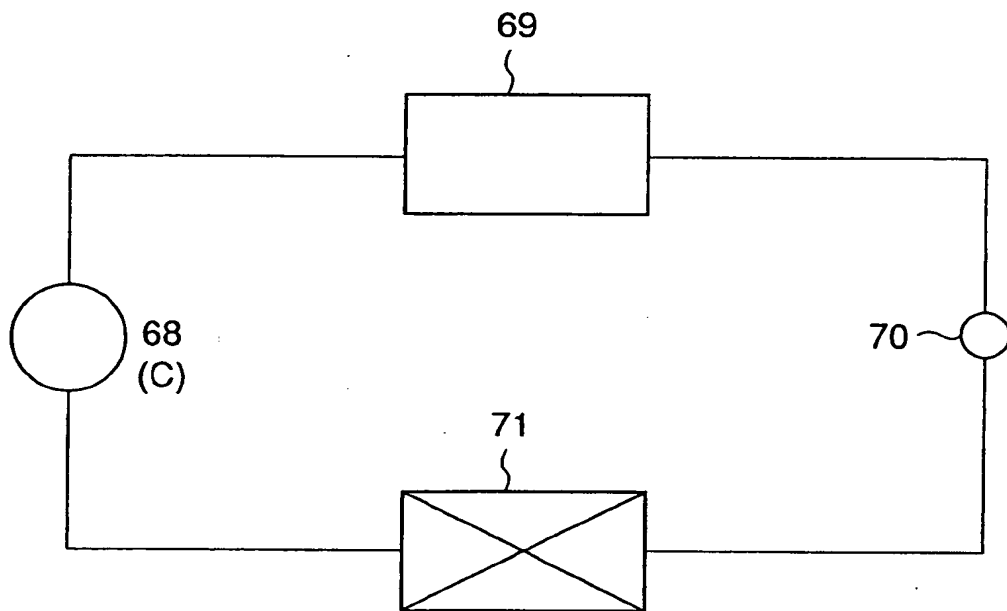
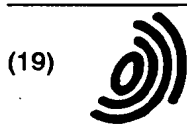


FIG.23







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- Tsuyoshi, Higuchi  
Ota-shi, Gunma-ken (JP)
- Kazuaki, Fujiwara  
Ota-shi, Gunma-ken (JP)
- Keijiro, Igarashi  
Ota-shi, Gunma-ken (JP)
- Masaaki, Takezawa  
Nitta-gun, Gunma-ken (JP)
- Kazuhiko, Arai  
Nitta-gun, Gunma-ken (JP)

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(71) Applicant: **Sanyo Electric Co., Ltd.  
Moriguchi-shi, Osaka (JP)**

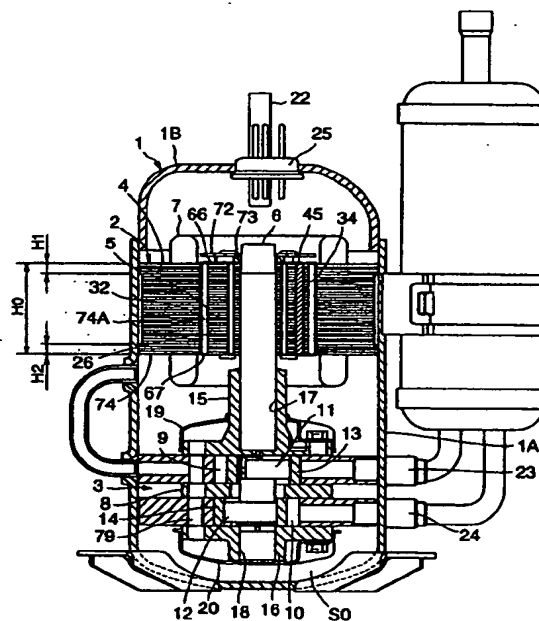
(74) Representative: **Glawe, Delfs, Moll & Partner  
Patentanwälte  
Postfach 26 01 62  
80058 München (DE)**

(72) Inventors:  
• Kenzo, Matsumoto  
Ora-gun, Gunma-ken (JP)  
• Manabu, Takenaka  
Ora-gun, Gunma-ken (JP)

(54) **Motor compressor and cooling apparatus using the same**

(57) An objective of the present invention is to provide a motor compressor that reduces noise by lessening a contact area between a stator and a shell, wherein a motor element is constituted of a stator having a stator core that contacts and is fixed to an internal wall of the closed vessel, and a rotator having a magnetic substance, which is attached to the rotating shaft and is rotatably supported in the inside of the stator construct. It is essential that  $H < H_0$  is satisfied wherein  $H$  is a dimension in a rotating shaft direction of an area in which the stator core contacts the closed vessel and  $H_0$  is a dimension in a rotating shaft direction of the stator core.

**FIG.1**



**EP 1 160 956 A3**



European Patent  
Office

# EUROPEAN SEARCH REPORT

Application Number  
EP 01 11 0759

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
Y	EP 0 622 885 A (SANYO ELECTRIC CO) 2 November 1994 (1994-11-02) * column 6, line 26 - line 43 * * column 16, line 25 - column 18, line 42; figures 38-43 *	1-7	H02K5/24
Y	GB 2 293 695 A (AISIN SEIKI) 3 April 1996 (1996-04-03) * abstract * * page 2, paragraph 4 - page 3, paragraph 1 * * page 4, paragraph 3 - page 5, paragraph 2 * * page 11, paragraph 2; figure 2 *	1,3,4,7	
Y	PATENT ABSTRACTS OF JAPAN vol. 2000, no. 08, 6 October 2000 (2000-10-06) & JP 2000 134882 A (MATSUSHITA ELECTRIC IND CO LTD), 12 May 2000 (2000-05-12) * abstract; figures 3,6,10 *	2,3,5,6	
Y	PATENT ABSTRACTS OF JAPAN vol. 1996, no. 01, 31 January 1996 (1996-01-31) & JP 07 236239 A (SANYO ELECTRIC CO LTD), 5 September 1995 (1995-09-05) * abstract; figures 1-6 *	6	H02K F04B
Y	US 5 818 131 A (ZHANG WEI-MIN) 6 October 1998 (1998-10-06) * column 28, line 66 - column 29, line 12; figure 21 *	7	
		-/--	
The present search report has been drawn up for all claims			
Place of search <b>MUNICH</b>		Date of completion of the search <b>15 March 2004</b>	Examiner <b>Türk, S</b>
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	
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EP0 FORM 1503 03.02 (P4/C01)



European Patent  
Office

# EUROPEAN SEARCH REPORT

Application Number  
EP 01 11 0759

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
A	PATENT ABSTRACTS OF JAPAN vol. 013, no. 446 (M-877), 6 October 1989 (1989-10-06) & JP 01 170778 A (DIESEL KIKI CO LTD; OTHERS: 01), 5 July 1989 (1989-07-05) * abstract; figure 1 *	1-3,5-7	
A	--- PATENT ABSTRACTS OF JAPAN vol. 2000, no. 07, 29 September 2000 (2000-09-29) & JP 2000 116172 A (TOSHIBA TEC CORP), 21 April 2000 (2000-04-21) * abstract; figures 1,2 *	2,6	
A	--- US 3 666 380 A (ELLIS CHARLES B) 30 May 1972 (1972-05-30) * column 2, line 15 - column 3, line 2; figure 1 *	1	
A	--- US 6 051 898 A (SAKAMOTO MASAFUMI) 18 April 2000 (2000-04-18) * column 1, line 19 - line 30; figure 1 *	2	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (Int.Cl.7)
Place of search <b>MUNICH</b>		Date of completion of the search <b>15 March 2004</b>	Examiner <b>Türk, S</b>
<p><b>CATEGORY OF CITED DOCUMENTS</b></p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons &amp; : member of the same patent family, corresponding document</p>			

EPO FORM 1503 03.02 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT  
ON EUROPEAN PATENT APPLICATION NO.**

EP 01 11 0759

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.  
The members are as contained in the European Patent Office EDP file on  
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15-03-2004

Patent document cited in search report		Publication date		Patent family member(s)	Publication date
EP 0622885	A	02-11-1994	JP	3485599 B2	13-01-2004
			JP	6323292 A	22-11-1994
			CN	1098826 A ,B	15-02-1995
			DE	69425921 D1	26-10-2000
			DE	69425921 T2	21-06-2001
			EP	0622885 A2	02-11-1994
			JP	7012079 A	17-01-1995
			KR	137417 B1	15-06-1998
			SG	52214 A1	28-09-1998
			US	5666015 A	09-09-1997
			JP	7012078 A	17-01-1995
			JP	7031087 A	31-01-1995
GB 2293695	A	03-04-1996	JP	8182277 A	12-07-1996
JP 2000134882	A	12-05-2000	NONE		
JP 07236239 2	A		NONE		
US 5818131	A	06-10-1998	NONE		
JP 01170778 2	A		NONE		
JP 2000116172	A	21-04-2000	US	6323574 B1	27-11-2001
US 3666380	A	30-05-1972	CA	948604 A1	04-06-1974
			DE	2142448 A1	09-03-1972
			GB	1364072 A	21-08-1974
			SE	377180 B	23-06-1975
US 6051898	A	18-04-2000	US	6225773 B1	01-05-2001
			US	6359349 B1	19-03-2002
			US	6320347 B1	20-11-2001

EPO FORM P4439

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82